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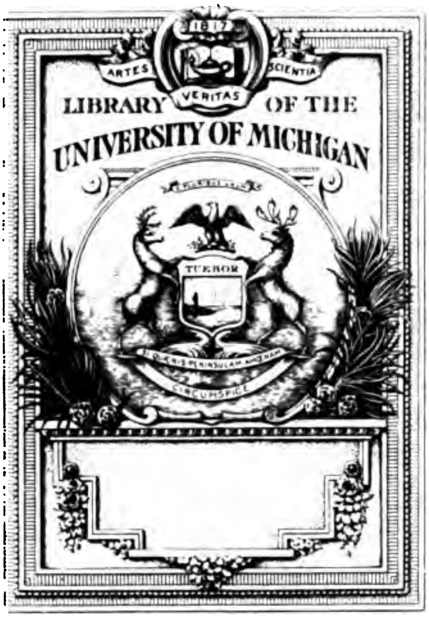

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Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
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Geological Map of the Districts of Hartley, Bowenfels, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.

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Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 50 chains to 1 inch.

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(2.) PUBLICATIONS.

The Mining Act of 1884, with Regulations.
Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.

Mineral Products of New South Wales, 1882, containing:—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

Mineral Products of New South Wales, 2nd Edition, 1887, containing:—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.

Memoirs of the Geological Survey of New South Wales.

Geology.

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.

Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales; and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)

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PREFACE.

Geological Surveyor-in-Charge to the Under Secretary for Mines.

Geological Survey Branch,
Department of Mines, 7 January, 1889.

Sir,

The Geological Survey staff and other officers of the Department of Mines occasionally make discoveries and observations regarding the geology, palæontology, and mineral resources of the Colony, which, being of scientific and general public interest, it is desirable to publish.

Such information includes reports upon the geological features of certain districts. The occurrence of the rocks, minerals, and fossils represented in the collections in the Mining and Geological Museum, and notes of special laboratory work; reference to the maps and other publications of the Department will also be given. It is proposed to issue this, as far as practicable, quarterly, in a series of Parts entitled "Records of the Geological Survey of New South Wales"; and it is hoped that this publication will be a means not only of stimulating research by private persons who may have the opportunity for carrying on geological investigations, but, by circulation amongst foreign mining and scientific institutions, may make more widely known the rich natural resources of New South Wales.

I have, &c.,

C. S. WILKINSON,

Geological Surveyor-in-Charge.

DEPARTMENT OF MINES, SYDNEY.

RECORDS
OF THE
GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. 1.] 1889. [Part 1.

I.—Notes on the Geology of the Barrier Ranges District, and the Mount Browne and Mount Poole Gold-fields: by C. S. Wilkinson, F.G.S., Geological Surveyor-in-Charge.

In the Albert District, which comprises the north-western portion of the New South Wales territory beyond the Darling River, there are three areas of Palæozoic formations (chiefly Metamorphic Silurian slates, granite, and Devonian strata) occurring in the midst of a wide extent of the Cretaceous and Post-Tertiary formations.

The larger of these areas, about 4,000 square miles, includes the Barrier Ranges, with the far-famed Broken Hill and surrounding silver-mining district, and the Poolamacca or Euriowie Tin Mines, &c. The two smaller are gold-mining areas—one situated near the town of Milparinka, 230 miles north from Silverton, or 180 miles north-west from Wilcannia, embraces the Mount Browne Range, 22 square miles in extent; and the other, commencing a few miles further to the north, the Whittabreena Ranges and "Granite" or Tibooburra Diggings, occupies an area of about 109 square miles.

The Barrier Ranges District as far north as Corona has already been partly described by me in the Annual Report of the Department of Mines for 1884,[*] and in a separate report upon its mining prospects, published by the Department in August, 1884[†]; also the northern portion of the Albert Gold-field has been examined by Mr. H. Y. L. Brown, Geological Surveyor (now Government Geologist of South Australia), whose report, in which special reference is made to the existence of artesian water, was published in 1881.[‡] The following notes were made by myself when, in 1887, I visited this gold-field with Mr. Harrie Wood, Under Secretary for Mines, and Mr. W. H. J. Slee, Inspector of Mines, as members of the Prospecting Board.

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[*] Page 146.

[†] Report on the Silver-bearing Lodes of the Barrier Ranges, in the Albert Ranges, &c., p. 12, and sketch (fscap., Sydney, 1884). Government Printer.

[‡] Report upon the Albert Gold-fields, &c., especially with reference to the existence of Artesian Water, &c., p. 9, three sheets of sections, and plan (fscap., Sydney, 1881). Government Printer.

This great metalliferous area, in which silver, lead, gold, tin, copper, bismuth, manganese, iron, &c., have already been discovered, consists chiefly of ranges of Silurian, granite, and Devonian formations, bounded on the west, north, and north-east by the Cretaceous formation with Post-Tertiary clays and drifts overlying the line of junction here and there. The boundary between the Palæozoic and Mesozoic formations commences close to Thackaringa, and near where the railway from Adelaide to Silverton and Broken Hill crosses the New South Wales and South Australian border, and runs in a north north-east direction, passing three miles west of Silverton and west of Corona; thence in an irregular curving line to the north and north-east, past Packsaddle Station, to the northern end of the Kooningberry Range, near Wonaminta; thence in a similar curving course south-easterly to near Mount Murchison, north of Wilcannia on the Darling River.

In places within this area occur open plains formed of Pleistocene or Post-Tertiary deposits; sand ridges of wind-blown origin are sometimes met with. The effects of denudation by wind action are very marked in this district. The surface in many localities is covered with pebbles of quartz, and of other rocks which were once embedded in the Pleistocene sandy clays; but by the force of the wind the sand and clay have been swept away, the pebbles which the wind could not remove remaining. I have often observed the exposed surfaces of projecting rocks in a highly polished state from the friction of the sand drifted against them by the wind.

The immense beds of cream-coloured limestone, which at Corona Station are about four hundred yards wide, and extend nearly north and south for at least twenty miles, consist of magnesian limestone, or dolomite. A sample of it collected by me gave the following analysis made in the Laboratory of the Department:—

Carbonate of Lime	53·05
Carbonate of Magnesia	42·03
Insoluble in acids (sand)	3·72
Oxide of iron, with traces of Alumina	1·38
	100·18

Much of it is a good building stone, but not well suited for lime-burning for agricultural purposes.

This is the first known occurrence in New South Wales of massive beds of magnesian limestone. I could not detect any fossils in them whereby their age might be known; and owing to the numerous intrusions of granite, and the extreme metamorphism that the sedimentary rocks have in places undergone in the Barrier

District, the geological horizon of these limestones will be difficult to determine without further close examination, but they appear to be associated with the lowest beds of Palæozoic rocks of the district, and are probably of Silurian age, or older.

About eighteen miles north of Corona Station (Mr. Harvey Patterson's) we pass from the Silurian schists on to the Cretaceous formation. The latter probably extends to the north under the flat sandy country in which Lake Bencannya is situated. Then the country is in places very sandy to Packsaddle Station, where the altered Silurian schists with quartz reefs of a promising metalliferous character appear again and form low rocky hills for seven miles further north.

The large extent of gently undulating country lying between here and the Mount Browne Slate Range consists of the Cretaceous strata, overlaid in places by Pleistocene alluvial deposits, and belts of recently formed wind-blown sand ridges, which rise to a height of from twenty to fifty feet above the general level of the country. Lake Cobham, which a few years ago was quite dry, at the time of our visit presented a fine sheet of water owing to the late rains, receives the drainage of this wide-spread, nearly flat country. It occurs about three hundred and sixty feet above the sea level, and occupies a large shallow hollow or depression into which runs the Evelyn Creek, draining the country beyond Mount Browne and Mount Poole. Having no outlet, its water, as it diminishes by evaporation, becomes brackish. When Lake Yantara, to the north-east, loses its water by evaporation in dry seasons, it is said that the salt which remains crystallized upon the surface is collected for use at some of the squatters' stations.

In the wells sunk in the Pleistocene alluvial deposits, and in the upper strata of the Cretaceous, the water obtained is nearly always brackish. There is, however, no doubt that by boring or sinking to a sufficient depth in the Cretaceous formation an unlimited supply of artesian water would be met with. There is abundance of earthy gypsum, locally called "Copi," present in patches over this country.

The township of Milparinka is situated about four miles east of the north end of the Mount Brown Range and on the Evelyn Creek, where there is one of the few permanent waterholes in the district. The hole has been formed by a stratum of sandstone lying across the lower end of it. This is a good site for the construction of an overshot concrete dam, which would afford the means of conserving a splendid supply of water. A well has been sunk on the north side of the town, and a little brackish water struck, which rose in the shaft to within sixty feet from the surface. If this were deepened by sinking or boring, I believe that fresh water that would rise to the surface would be obtained. The formation is Cretaceous, and in the town several small quarries have been opened in nearly horizontal beds of sandstone grit from one to five feet thick, showing current-bedding (which dips W. 10° N. at from 25° to 35°), and vertical joints striking W. 40° S. and E. 20° S. The sandstone forms good building stone, and has been used for the court-house and other buildings;

it contains obscure impressions of plant stems. Beneath one bed of sandstone is a stratum of conglomerate containing pebbles of quartz and altered sandstone, some of the pebbles being more than one foot in diameter.

The surface of the Cretaceous country is almost level, with the exception of a few denuded hollows, from Milparinka to the foot of the Mount Brown Range, which rises in a north-east and south-west direction like an island out of the Cretaceous area.

Four and a quarter miles from Milparinka, on the road to the Mount Brown Diggings, a gully draining from the range has been eroded to a depth of about twenty-five feet through the Cretaceous beds, and exposed the underlying Silurian slates and sandstones striking about north-north-west and traversed by quartz veins. A promising-looking quartz reef crosses the track about a quarter of a mile further on. Then the track follows almost along the junction of the Cretaceous and Silurian which approximately marks the shoreline or beach of the Cretaceous ocean.

Where the small gullies draining off the Mount Browne Range cross this line, gold has been concentrated and worked in their alluvial deposits, especially at the "Four-mile" and "One-mile" Diggings; and also between the gullies "surfacing" has been carried on along the line of junction. At the "One-mile," the gold has been traced below the Cretaceous for about a quarter of a mile from the margin; and in one shaft, the "Lady Anne," gold is obtained in a run or lead forty feet wide with fifteen inches of wash. At Mount Browne the gold first worked in the surfacing has been followed south-west from the slate outcrop in shafts increasing in depth to two hundred and twenty-two feet, as in the "All Nations," "Golden Lake," and "Sons of Freedom," &c., which have been sunk in the Cretaceous formation, consisting of coarse, rounded quartz pebble drift, gypseous marl, quartzite conglomerate, and blue clays, with impressions of plant stems, &c.; in the "Golden Lake," "Blacksmiths," and "Waterwitch" claims, at two hundred and forty feet, heavy water was struck, and the shafts not bottomed. It is to prospect for the continuation of the gold-bearing wash into this wet ground that the miners have sought for the Government aid. A nugget of gold weighing 28 oz. has been recently obtained. These Cretaceous beds surround the end of the Mount Browne Ranges at this point, and there is much probability of rich patches of gold being got in the gravels along this old shore line on both the east, west, and south sides of the range.

The range consists of highly-cleaved vertical clay slates and sandstones, strike N. 35° W., traversed by lenticular ferruginous quartz reefs of all sizes up to fifty feet wide, some of which have doubtless supplied gold to the drifts. Gold, both alluvial and reef, is reported to have been found within six miles to the north-west and round to the west and south-west. This is a promising field and many claims might be worked on the margin of the Cretaceous; and within half a mile from this, shafts, less than three hundred feet deep might be sunk, and abundance of good water obtained, which could be pumped up to ground-sluice the deposits, and for other mining purposes.

The margin of the Cretaceous and Silurian series is about one hundred and twenty-five feet above the level of the town of Milparinka.

The surface of the country is covered with pebbles of all sizes up to eighteen inches or more, principally of quartz, with some of slate, altered sandstone, and quartzite; they have been left by wind denudation. The strong winds chiefly come from the north in the month of October.

From Milparinka, for a distance of ten miles on the road to Tibooburra, the Cretaceous formation is covered chiefly with quartz and sandstone pebbles; there are also a few patches of calcareous sandstone horizontally stratified. This class of country, which at the time of our visit was well covered with grass, saltbush, and cottonbush, extends to "Good Friday Diggings," two-and-a-half miles north-east of Mount Poole. Here are shallow alluvial and "surfacing" deposits on the south-east slopes of slate ranges, and near the edge of the Cretaceous. In the slates very large "blows," or lenticular reefs of quartz crop out and strike about north-north-west. Some of the gold obtained is water worn, and some sharp and angular; the latter has evidently been derived from some reefs close at hand. About twelve miners were working the ground. From here the track passes over the slate ranges, and immediately crosses an elvan dyke with quartz reefs on the east side of it; other reefs occur near in soft clay slates. In one of the gullies draining this slate area there are shallow gold workings. Then the track follows up the Warratta Creek to where a quartz reef has been worked to a depth of two hundred feet, but is now idle, though a battery of twelve stamps is there. In 1884 a crushing of 125½ tons of quartz yielded 39 oz. 3 dwt. of gold. Other promising reefs occur near on west side of the main worked reef. This reef has been traced for about three miles; it strikes N. 22° W. and is from six inches to two feet wide. The alluvial along the creek has been worked for gold, and one nugget obtained weighed 13 oz. The track follows up the about two miles from the reef, and then passes over a gap in the slate range at an creek elevation of four hundred and seventy feet above Milparinka, and follows down a gully which has been worked from its head for about two miles in a north-easterly direction, to where it suddenly emerges from the slate ranges and flows over the Cretaceous plains, which are pebbly with calcarous sandstone and gypseous marls, to Nuggetty Gully where the slate hills again rise out of the Cretaceous country. Along the margin of the latter, as well as on the slopes of the slate hills, there are shallow alluvial workings. These continue to Tibooburra; but the slate gives place to granite about one-and-three-quarter miles before reaching Tibooburra. Rich "surfacing" has been found more or less over the granite area, near the centre of which the town is situated. This area is in irregular outline about two to three miles in diameter. The granite is hornblendic with black mica and oligoclase felspar and traversed by veins of eurite. In one part there is a mass, twenty feet across, of large crystals of orthoclase, quartz, and yellow mica. It shows vertical, parallel cleavage joints, which split up the rock and give it the appearance of strata standing on end. The joint fissures strike N. 35° E. The granite contains pieces of other rock. On the surface it weathers into patches of hard boulders, which show the effect of scaling and breaking up from the action of weather, probably heat and cold. Between these patches it appears to be of a softer nature, or more subject to decomposition, and has been worn to a comparatively level surface, covered with from one to six feet of alluvium, which contains gold, and has in places been wholly worked. The gold in it is scaly, but some shotty and nuggetty gold has also been found. It appears to have come out of the granite, which is traversed by a few reefs of quartz. Gold is only found in payable quantity in a belt about three-quarters of a mile wide, extending east and west across the granite. The granite is surrounded by altered slates and sandstones highly cleaved, and containing large and small lenticular reefs of quartz. One reef is about twenty feet thick. The slates strike W. 32° N., and are vertical. On the north-east and south there is only a narrow belt of slates between the granite and Cretaceous; but to the west it extends for six miles or so, forming rough rocky hills, the gullies draining from which have been more or less worked for gold, especially where the Cretaceous gravels have been denuded off the slates, as at the "Six-mile" and the "Two-mile" Diggings. The Cretaceous strata consist of shale, calcareous ferruginous sandstone and pebble cement. The surface of the ground is generally covered with pebbles, chiefly of quartz and altered sandstones. Three miles east of the town a well has been sunk through blue clay shale beds, and an abundant supply of water struck at one hundred and ninety-five feet deep; it was not bottomed. Also in Scot's well in similar strata, at two hundred feet deep, a good supply was met with, which rises sixty feet in the shaft. The Government well is in slate, and yields only a little brackish water. About one mile from Tibooburra a patch of sandstone and conglomerate, about ten chains in diameter, occurs. The sandstone forms excellent stone of white and brown colour for building purposes. It is false bedded, and somewhat resembles some of the Devonian strata, and contains obscure impressions of plants. About half a mile east of the town another small patch of these rocks, only about thirty yards across and twenty-five feet thick, rests upon the granite.

Similar rocks, though containing more conglomerate rest on the slates and cap the range about eight miles west of Tibooburra, just beyond Nuggetty Gully, thus showing that this formation must have once covered nearly all the granite and slate area of this locality; and it is evident that where it has been removed by denudation during the erosion of the valleys, the gold in it originally derived from the slates, reefs and granite has been ground-sluiced, as it were, into the shallow alluvium in the bottom and on the sides of the existing valleys. At the head of a small gully which has been worked for gold, and in which a 20-oz. nugget is said to have been obtained, a tunnel has been driven seventy-three feet into the Cretaceous conglomerate, where it rests upon the slates, and "colours" or specks of gold were obtained, but not in payable quantity.

In Nuggetty Gully a 15-oz. nugget, with quartz attached, was obtained, also smaller specimens of gold in quartz, but the gold is chiefly fine and scaly, as if derived from the laminæ of the slates as well as from quartz veins; the reefs in this locality should be tried for gold. Between the "Nuggetty" and "Easter Monday" Diggings, where some surfacing on the slates has been carried on, the thin capping of Cretaceous conglomerate will probably furnish many payable patches. Most of the workings in the alluvium and surfacing are where the Cretaceous gravels have been denuded from off the slates. This may be considered a shallow surfacing diggings, and a large amount of gold will for years be won from it. In places, however, the gold may probably be traced into deep ground in the Cretaceous, where the latter has filled irregular hollows in the slate bed-rock; but no Tertiary deep leads exist in the district, excepting, perhaps, in the Warratta Creek flat, where it leaves the hills and crosses the road from Tibooburra to Milparinka. The alluvium of this flat between the slate hills, about a quarter of a mile west of the road and north of the Warratta gate, should be prospected. The next creek flat, a short distance south of the Warratta gate, should also be prospected. To the south-east of Warratta gate the slate formation with quartz reefs continues for about five miles; and in one part, in a gully on the south-west slopes, gold in the alluvial has been worked for about half a mile, and at the head of the workings several quartz reefs cross the gully, one of which has been sunk upon for about twenty feet, and is said to have yielded gold. The slate contains cubical pyrites.

The Mount Browne Range attains its highest point (which is about four hundred and fifty feet above Milparinka) W. 20° S. from Milparinka; then in about one-and-a-half miles it terminates as a conspicuous range; but a low rise continues from it to Mount Poole. Slates with quartz reefs, crop out at intervals along this rise, and elsewhere it is covered with Cretaceous quartzites and conglomerates.

On the west side of it the surface of the Cretaceous formation stands at a higher level than that on the east side; for the drainage of a large area finds its way into Preservation Creek, through a rocky gorge eroded one hundred feet deep in the slate and diorite at Depôt Glen, where a fine waterhole exists just where the creek emerges from the gorge. Other good waterholes occur in the creek bed a little further down: on the southern bank of one is the grave of J. Poole, who was buried here 16th July, 1845, when the gallant explorer, Sturt, and his party, of which Poole was the surveyor, who were the first to visit this country, were so long detained here during a season of drought. About two miles west-north-west from Depôt Glen the Silurian schists strike about N.W. to N. 35° W., with quartz reefs of irregular extent, and pass under the Cretaceous.

Mount Poole, three hundred and eighty-five feet above Milparinka, rises somewhat abruptly—about two hundred and twenty feet—above its base, up to which the surrounding country gradually rises. It forms a rough, rocky hill about one-and-a-quarter miles in diameter, with a central peak, on which Sturt, in 1845, built a cairn of stones ten feet high.

The Mount consists of hard quartzite (porcellanite, which rings, when struck, like procelain), quartzite conglomerate, and accretionary quartzite; on the north slope white and grey clays, with ironstone patches crop out. It appears as if the Mount had been formed by a local upheaval of the Cretaceous beds, for its summit is about two hundred and sixty-five feet above the level of the highest quartzite rises, which occur between Milparinka and Tibooburra. The quartzite beds are similar to those forming the cap of "Tent Hill," eight miles north of Corona, referred to in my Annual Report for 1884*; they appear to form the uppermost beds of the Cretaceous series, as pointed out by Mr. Geological-Surveyor Brown in his report on the district in 1881. Probably artesian water would be struck at four hundred or five hundred feet if a bore were put down on the west slope of this Mount—at about one hundred feet below its summit.

The surface of the country for two to three miles from Mount Poole is thickly strewn with pebbles of quartz, boulders of quartzite, quartz, and other rocks mingled with a sandy clay. At present (September) it is covered with grass, saltbush, cottonbush, and other herbs, but in seasons of drought it must appear quite as a "stony desert."

The Silurian formation of the Whittabreena Ranges appears to come in about seven miles north-east of Mount Poole. The highest point of the Whittabreena Range is called Wizard's Peak.

On the Silurian slate formation, and especially on its margin with the Cretaceous from Mount Browne to Tibooburra, payable deposits of gold are likely to occur, and probably a Pleistocene lead may be found on the Cretaceous as a "false bottom" for a distance of half a mile from the Gorge at Depôt Glen; this ground should be prospected. The slates with quartz-reefs crop out within about two-and-a-half miles W. 30° S. from Milparinka, and a little gold has been found there.

From the foregoing observations it will be seen that within the Silurian and granite areas metalliferous lodes of value have been worked, principally containing silver, lead, gold, and tin. Much of the country has not yet been prospected, so that the mining industry in this district, which has already attained a position of importance, will undoubtedly increase and support a large and thriving population. Mr. Warden De Boos reports that the quantity of gold raised during 1887 in the Mount Browne and Tibooburra Gold-fields was 4,709 oz.; and Mr. Wyman Brown, Warden of the Silverton Division, states that the value of the minerals exported in 1887 from the district under his charge amounted to £600,000, of which the Broken Hill Proprietary Company's Mine contributed lead and silver to the value of £464,190, from which £200,000 were paid in dividends.

A great desideratum is a good water supply. The low average annual rainfall, about nine inches, in this arid region precludes the permanency of a large supply in the natural holes in the water-courses; but it has been proved to be sufficient to afford an ample supply if large and deep tanks or dams were constructed to conserve it, and for which the hilly metalliferous country offers suitable catchment areas and sites. In the same country, that is, in the Palæozoic rocks, there is but little hope of obtaining, either by boring or sinking, an abundant supply of water fit for domestic use. However, the surrounding Cretaceous strata will be found to yield an unlimited artesian supply of fresh water.

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* Annual Report, Department of Mines 1884, p. 148.

Where the soil does not contain much saline matter, irrigation for cultivation purposes answers admirably. In the garden of Mr. Harvey Patterson, at Corona Station, also in the Chinamen's gardens at Tibooburra and Milparinka, which are irrigated with water from wells, I saw in the month of September splendid crops of vegetables, cabbages, onions, parsnips, and carrots four inches in diameter, white turnips five inches, and wheat standing from three to four feet high.

We cannot doubt, therefore, that the natural resources of this portion of New South Wales are sufficient, if intelligently made use of, for the settlement and health of a large population.

II.—Report on the Discovery of Human Remains in the Sand and Pumice Bed at Long Bay, near Botany: by T. W. EDGEWORTH DAVID, B.A., F.G.S., Geological Surveyor, and ROBERT ETHERIDGE, Junr., Palæontologist.

[Plate I.]

I.—Geological Description of the Locality.

ON April 14th ultimo, when examining the Sand and Pumice bed at Long Bay, we accidentally discovered in it portions of a human skeleton. This bed forms the surface of a tongue-shaped flat at the mouth of a small creek opening into Long Bay. To the north-east and south-west this flat is bounded by low hills of Hawkesbury Sandstone, partly covered by blown-sand, now overgrown by trees and scrub. To the north-west it gradually ascends and narrows until lost in the sand-hills similarly covered with vegetation, which form the source of the creek. Seaward, where the flat is about ten chains wide, it terminates in a low cliff of Hawkesbury Sandstone, the base of which is hardly removed above the level of high water. At the south-west end of the flat the cliff is twenty-six feet high, and from here it declines towards the right bank of the creek, where it is seventeen feet above high water-mark.

Three deposits are exposed in this cliff-face (see longitudinal section Pl. I, fig. 1) and are from below upwards:—

1. Hawkesbury Series.
2. Consolidated Sand, formed from waste of No. 1. *
3. Blown Sand and Pumice bed, with marine shells.

No. 1. The Hawkesbury Series consists of a whitish-grey quartzose-sandstone, with occasional lenticular beds of small quartz pebbles, and near the sea-level an intercalated bed of sandy-shale. At the left of the section, this series consists of a massive bed of a rather soft clayey sandstone, then twelve feet in thickness. Above this is a bed of dark-grey sandy-shale some two feet in thickness. This is again succeeded by a ferruginous decomposed sandstone, with pebbles and grit in places. The Hawkesbury rocks here dip south-westerly at a low angle, but a few yards to the right they roll over sharply to the north, so as to bring the shale-bed down to the high-water level.

No. 2. The Consolidated sand consists of sand with small fragments of quartz, and is here four feet thick, but increases on the right of the section to twenty feet. This deposit rests in a hollow of the Hawkesbury Series, partly due to this roll. From the point where the skeleton was found the consolidated sand thins somewhat towards the creek owing to its surface slope in this direction, and to the rising again of the underlying Hawkesbury Sandstone. Its upper surface for about 1 foot downwards is blackened with peaty material and very much hardened, showing clear evidences of having been at one time a land surface. No organic remains of any kind, nor any fragments of pumice were found in this bed. The surface of the consolidated sand was slightly hollowed at the point where the remains were found, but with this exception it was remarkably even, as far as could be seen in the excavation made, and along the cliff face.

No. 3.—The Blown-sand bed with shells and pumice is a loose whitish-grey sand, which was originally, no doubt, blown into its present position, and subsequently became overgrown with vegetation. The bed commences about one chain to the right of the point A in the longitudinal section, and extends to the right bank of the creek, a distance of three chains, maintaining a pretty uniform thickness of three feet. The fragments of pumice vary from one to two inches in diameter, and are most numerous for about two chains from the creek in a westerly direction, whence they die out gradually. The bed is here seventeen feet above high-water mark, and this is the greatest height to which we have been able to trace the pumice at this locality. Scattered through the turf, and the upper part of the bed, are numerous large shells,

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* Confirmatory evidence to the effect that this formation is distinct from the Hawkesbury Series, and is not merely the latter decomposed *in situ*, is supplied by a section recently observed by one of the authors near the south end of Fingal Bay, Port Stephens, where a bed of consolidated sand, about fifteen feet thick, similar to that at Long Bay, and probably of Tertiary Age, overlies a Palæozoic Porphyrite. The intermixture of peaty material with the consolidated sand at Fingal Bay proves clearly that it belongs to a far more recent date than that of the Hawkesbury Series.

chiefly belonging to the genera *Turbo* and *Triton*, with a few pebbles of sandstone, the largest of which is about nine inches in diameter. The surface of the flat, although now cleared of timber, shows evidence, chiefly in the form of old large stumps, of having supported as vigorous a vegetation as the surrounding low hills. It is further quite clear that this bed acted as the soil of these trees and shrubs, and was not simply accumulated round the trunks of pre-existing vegetation.

II.—Remarks on the Skeleton and its position.

The skeleton was first noticed owing to the fact that the lower end of the right fibula projected about an inch beyond the vertical face of the blown-sand, just at its junction with the consolidated sand. This bone had been so exposed, owing to a footpath having been made in the face of the cliff. The trend of the cliff face is about E. 25° N., and the fibula with the tibia beside it were lying about N. 30° W (Pl. 1, fig. 3). Following them in a direction N. 38° W., their upper ends were found in apposition with the patella and femur. About six inches to the right were the tibia and fibula of the other leg, lying nearly parallel with them, and also joined to their respective patella and femur. The femora were lying in a direction about W. 10° S., and resting on one of them, and attached to it by matrix were two specimens of the marine bivalve *Circe scripta*, Linn. The heads of the thigh bones were found inserted in the acetabula ; and the front of the pelvis was upwards, the right side being a little higher than the left, as though the body had reposed partly turned over on its left side. Under the left ilium were two stone implements, the smaller resting on the larger, and the convex valve of *Pecten funatus*, Reeve, whilst close by were several specimens of the *Circe*, some having the valves united. The ilia were united by only two vertebræ of the sacral series, and the others were not found, with the exception of the terminal bone of the coccyx. In contact with the upper sacral vertebræ was part of the spinal column, consisting of five lumbar and three dorsal vertebræ. The lie of the column was about W. 35° N. Portions of seven ribs were found partly resting against the vertebræ, and partly underneath. On the north side of the column, and close to the uppermost dorsal vertebræ, lay the lower arm bones of both arms, lying in a direction about N. 18° E. The bones of the hands were found in their proper places. Subsequently some of the bones of the feet were found by Mr. C. S. Wilkinson and Mr. J. E. Carne in the fallen sand at the foot of the cliff. It will thus be seen that of the whole of the upper portion of the skeleton, comprising the remaining vertebræ, humeri, sternum, clavicles, &c., and skull, no trace could be found after a very diligent search.

The bones were mostly in a fair state of preservation, though a few were so friable as to hardly bear lifting. None of them show traces of having been subjected to any kind of violence.

From the fact that the epiphyses of the tibiæ, femora, and radii, &c., were unossified, and the sacral bones not anchylosed, as well as from the general slenderness of the bones, our friend, Dr. H. C. Moir, of Summer Hill, who kindly examined them, is of opinion that they belonged to a young person not exceeding twenty years of age. The narrowness and shape of the pelvis clearly show the skeleton to have been that of a male.

The bones were resting immediately on the discoloured and hardened surface of the Consolidated Sand (Pl. 1, fig. 1, No. 2), which had been roughly excavated for their reception to a depth of about six inches, and forming an oblong depression three-and-a-half feet by two-and-a-half feet. The hollow was scarcely large enough to have held the skeleton when complete, if placed in the ordinary prone position. The bones were surrounded and overlain by loose whitish sand of the Blown-sand and Pumice bed (*Ibid*, No. 3), but throughout it were lumps of the loamy and hardened upper portion of the underlying bed (*Ibid*, No. 2), varying in size from that of a marble to that of an orange. These lumps were met with laterally only as far as the edge of the hollow, and vertically to within about one foot of the grass-level. The latter superincumbent material consisted of loamy Blown-sand forming the present land surface. A great number of specimens of *Turbo torquatus*, Martin, mostly broken, were distributed throughout this top layer, with occasional fragmentary examples of *Triton Spengleri*, Chemnitz. Four fragments of sandstone were found in the turf just over where the skeleton reposed. These were from six to nine inches, or even a foot in diameter, and rounded, evidently having been carried up from the beach. Similar pieces of sandstone were observed close to the right bank of the creek in the pumice bed.

III.—Objects immediately associated with the Skeleton.

As before stated, these consisted of two stone implements and some marine shells. The former are composed of a dark micaceous flagstone, which may have been obtained from local beds in the Hawkesbury Series. The larger (Pl. I, figs. 4 and 5), which is roughly oblong in shape and angular, measures five inches long by three wide, and is from three-eighths to half-an-inch in thickness. One of its longer margins has been ground down on both sides, so as to form a tolerably sharp-cutting edge. The smaller implement (Pl. I, figs. 6 and 7), is oval, and measures two inches in its longest diameter by one-and-a-half inches in the opposite. Mr. J. Brazier, C.M.Z.S., has examined these weapons at our desire, and considers them to be aboriginal skinning-knives, though of an unusual type, and one with which he is not well acquainted, as well as of considerable antiquity. We have, however seen a very similar knife to the larger of our specimens taken from the grave of an aboriginal in a "Kitchen-midden" at North Harbour, who perhaps died from the epidemic of small-pox, which raged amongst the blacks at Port Jackson at the commencement of the present century. It is possible, and even probable, that the implement found by us may be far older than that date.

The associated shells have been already mentioned, viz., *Pecten funatus*, Reeve, the convex valve found under the left ilium; *Circe scripta* Linn., two examples attached to one of the femora, and several under and around the arms. In the case of this bivalve, several of the valves were united, and one of them was found to be empty, although the others were partially filled with peaty matrix. Both species are edible.

IV.—Evidence for and against Burial.

That the skeleton was buried by human agency in the first place, and covered up to a great extent naturally by the drifting of sand afterwards, strong proof is afforded—

(1.) By the existence of the hollow in which it was lying.

(2.) By the fact that the material broken out of the depression was found to be scattered through the loose sand for a height of two-and-a-half feet above the bones.

The latter fact proves conclusively that this hollow was formed artificially, and was not a natural depression in the old land surface.

Glancing at the other phase of the question, viz., as against the fact of burial, we find that the only argument of any weight is the incompleteness of the skeleton. The body must obviously have been complete or incomplete at the time of its interment. If complete, and if it had been buried, as we now find it, under at least three feet of sand, it is scarcely credible that the only beast of prey of any capacity existing on the continent, as the native dog, could have scratched to such a depth and dragged away the upper part of the body and skeleton. On the other hand, if incomplete, the latter must have been severed either by man or animals. It is, however, difficult to conceive that aboriginals (and there seems little doubt that this is the skeleton of one), could have accomplished such a task, armed with no more serviceable tools than sharpened stones. If it be granted that the body was severed previous to burial some traces of violence could not fail to have been left on the bones at the point where the severance was made. As a matter of fact, however, neither the uppermost dorsal vertebra, nor the heads of either the ulnæ or radii show the least sign of anything of the kind.

The occurrence of the scattered and rounded pieces of sandstone in the uppermost layers of the Sand and Pumice Bed (Pl. 1, fig. 1, No. 3), over the spot occupied by the skeleton is probably accidental. It does not appear to have any relation to the custom prevalent with some of the Victorian blacks of placing the body in "a stone-lined trench cut in the ground."* That a custom somewhat analogous to this existed amongst our coastal blacks is evident. Mr. P. R. Pedley has shown us an aboriginal burying-place in Port Jackson, where stones, as proved by himself, had been placed immediately over the spot occupied by the corpse, the skeleton in this case having been found about one foot below them; but here the slabs were placed with method, and, clearly for a purpose.† The stones in the highest layer of the Sand and Pumice

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* R. B. Smyth, Aborigines of Victoria, 1878, I, p. 99.

† This method of protecting the dead seems to have been widely distributed.

Bed at Long Bay are much smaller than those obtained by Mr. Pedley, and as others were observed at another point, at least two chains distant, they may have had no connection at all with the burial.

Referring again briefly to the incompleteness of the remains it is a remarkable fact that the depression in which the bones lay was only sufficiently large for them in their incomplete condition. It could not have received a corpse buried in the ordinary extended position. But amongst certain tribes of Australian blacks it was the custom to inter it "bent and doubled, so as to admit of its being laid in a small space,"* usually with the thighs drawn up against the trunk.† This, however, could not have been the case in the present instance, as evinced by the position of the skeleton shown on the plan.

V.—Probable Explanation of the Conditions of its Occurrence.

Adopting the theory that the body was buried by human agency, and in a complete state, we venture to suggest the following explanation of the conditions of its occurrence:—At the time of the youth's death the top of the old land surface (Pl. 1, fig. 1, No. 2) was thinly covered with drift sand to the depth of a few inches, for, had it acquired anything like its present thickness, the aboriginals would probably have interred the remains in this loose sand without going to the trouble of excavating in the hardened material of the old land surface.

There being at the time no loose sand of serviceable thickness available, a shallow excavation was made to the depth of about six inches, and the body laid in it, the head and shoulders perhaps resting on the edge of the hollow. It was then covered partly with the excavated fragments of consolidated peaty-sand, and partly with what little loose sand was lying about. After, or during decomposition, the covering material was either blown away or scratched from around by wild dogs, and the missing portions of the body dragged away by the latter. The drifting of the sand then continued until it reached the level of the present surface, when vegetation sprang up, and the whole was gradually bound and compressed into its present solidified form, and supported trees of considerable size, as shown by the stumps still remaining in the ground. Such strong signs of marine denudation are apparent in the bay, that the cliff without doubt then extended further seaward than it does at the present day.

VI.—Age of the Skeleton.

The only substantial evidence for assigning a comparatively recent date to this burial is in the fairly good state of preservation of the bones. This can, however, to some extent be accounted for by the dry nature of the surrounding soil and excellent drainage of the hollow in which they lay.

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* Smyth, *loc. cit.*, p. 27.

† This appears to have been the position adopted by the coastal blacks of the Port Jackson district.

On the other hand, the evidence for tracing these remains back to a very early period of man's occupancy of this country may be briefly summed up as follows :— First, the quantity of the superincumbent material accumulated subsequently to the interment; secondly, the position of the grave with regard to the then and now-existing cliff face, illustrating the amount of denudation which must have taken place; thirdly, the probable antiquity of the associated stone implements.

An estimate of the rate of increase of Post Tertiary deposits is governed by such variable data that it is hardly possible to assign even an approximate date to the burial of the Long Bay's skeleton. It must, however, be very old—old enough to allow a well-marked geological deposit, such as the Sand and Pumice bed, to accumulate over it. The advent of man on this continent is still wrapt in obscurity, and probably will remain so—certainly until we possess more definite geological evidence of his presence than we at present have before us. So little general interest has been manifested in the natural history of the aboriginal inhabitants of this part of Australia as almost to amount to a national disgrace. Their burial-mounds, "Kitchen-middens," and other traces likely to become geologically interesting, are disappearing so fast through the rapid march of "improvements," that ere long few or no traces will be left. It is, therefore, much to be regretted that some systematic and scientific method of investigation of the early history of this fast disappearing and ill-used race be not forthwith established. We have in the present case probably one of the earliest traces of man yet discovered.

We are acquainted with but two other instances of human traces occurring under geological conditions. The first is that of the "stone hatchet found on the Bodalla Estate, near Moruya, in the alluvium, at a depth of fourteen feet from the surface."* Mr. Wilkinson was informed that a large tree was growing immediately on the surface over the spot where the hatchet was discovered. The second was observed by Mr. C. S. Wilkinson in 1864, when making a survey of the Otway Ranges, in Victoria. In the sand dunes, two miles east of Cape Otway light-house, flint chips, a sharpened stone tomahawk, and several bone spikes or needles were found, relics of the past tribes of the Cape. At about the same distance from the light-house one of the writers, in company with Mr. H. Ford, of that place, obtained a similar bone spike in a mixture of beach material, pebbles, humus, and broken shells, resting on the Mesozoic Carbonaceous sandstone, forming the high cliffs of the Cape, and apparently intermediate between that deposit and the overlying dunes.† Remains of this nature, lying, as they did, beneath sand dunes at least two hundred feet high, must have been of great antiquity.

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* C. S. Wilkinson, Mineral Products, &c.—2nd edit, 1887, p. 90.

† Etheridge, junr., "Observations on the Sand Dunes of the Coast of Victoria," *Trans. R. Soc. Vict.*, 1876, xii, p. 3.

III.—Petrographical Notes on the Eruptive Rocks connected with the Silver-bearing Lodes at Sunny Corner, near Bathurst, New South Wales: By WILLIAM ANDERSON, Geological Surveyor.

[Plates II and II *a*.]

THE igneous rocks in immediate connection with the Silver-bearing Lodes at Sunny Corner, some twenty miles east of Bathurst, consist of quartz porphyries and non-porphyritic felsites. They are intrusive, and have been erupted through a series of Palæozoic rocks, probably of Silurian age. They occur in four isolated areas (Pl. II); but although their outcrops are separated at the surface by Silurian sedimentary rocks, yet there is no doubt that they had their origin in the same eruptive force. In fact, the continuity of the three larger areas is proved by the occurrence of quartz porphyry in the shaft of the Great Mitchell Extended mine, on Mineral Lease 20, parish of Castleton. One of the larger areas forms the hill immediately to the south-west, another lies to the south-east of the township of Mitchell, while the third forms Township Hill. The fourth and smallest area lies about two miles to the north of the township, but is, however, connected with one of the felsite dykes which runs north from Township Hill, by a narrow belt of highly altered, and probably faulted Silurian strata. The two larger areas to the south of the township consist of quartz porphyry, but no metalliferous lodes have been discovered in immediate connection with them, although numerous gold-bearing quartz reefs have been opened up, both along their lines of contact with the slates and in their mass. The principal silver lodes occur in connection with the eruptive rock forming Township Hill, which is one of the highest hills in the neighbourhood. At its southern end the rock is a typical quartz porphyry, while towards the north this intrusive mass breaks up into three well-marked dykes consisting of non-porphyritic felsite, and traversing the slates in a general northerly direction. It is in connection with these narrow felsite dykes that the chief silver lodes occur, the Sunny Corner mine being connected with the western; the Great Western, and Silver King mines with the central; and the Silver Queen mine with the most easterly. The Nevada mine is situated near the western boundary of the smallest of the eruptive areas, about two miles to the north of the township.

Besides the acquaintance with these rocks which I gained in the field whilst making a geological sketch map of the neighbourhood of the silver lodes, in the latter end of 1886, I have examined microscopically a series of thirty thin rock-slices taken chiefly from the intrusive mass to the south-east of the township, from the Township Hill, and the felsite dykes connected with it, and from the Nevada mine. Although these sections are taken from intrusive masses which in all probability were erupted at one and the same time, yet, owing to the varied conditions under which different portions of them consolidated, they present in their extreme variations of rock structure two distinct varieties of rock, quartz-porphyry and non-porphyritic felsite. There is, however, a distinct transition from the true quartz porphyry into the non-porphyritic felsite by the lessening in size and abundance of the porphyritic constituents. This gradation is seen in the series of sections taken from south to north on the Township Hill, and shows conclusively that the non-porphyritic felsite dykes are simply offshoots from the general eruptive mass, and that their fine-grained structure and want of porphyritic ingredients are due to the rapidity with which they parted with their heat, causing them to consolidate before the felspar and quartz had time to separate out in a porphyritic form. In all the sections of this intrusive rock the devitrified base is seen microscopically to be of a similar nature, and the only difference macroscopically between the two varieties is the presence of porphyritic minerals in the quartz porphyries. The felsites are in most cases distinguishable with difficulty, even by the aid of a lens, from the altered pyritous slates which they traverse.

The quartz-porphyry is of a light gray, brown, or reddish colour, the last being, however, rare. Specimens taken from different parts of the out-crops present different varieties of structure. Besides the typical form of quartz-porphyry which shows no characteristic peculiarity of structure, there is the banded variety showing fluxion structure, and the sphærulitic variety, where the base is crowded with sphærulites. Microscopically, the devitrified portion of the base is made up of microcrystalline quartz and felspar grains, in some sections the former mineral predominating, and in others the latter. These minute quartz and felspar grains can only be distinguished by their action on polarized light under a high power. Between crossed nicols, however, besides this individualized quartz and felspar, fine reticulations which have no action on polarized light are seen inclosing the crystalline grains of the devitrified portions of the base. This is probably a microfelsitic or still glassy portion of the base. The base is never altogether colourless, but is usually of a yellowish-brown, or rarely red colour, due to the presence of ferrite in varying abundance. It has generally a more or less streaky appearance, and this is a very prominent feature in those sections which show a distinctly fluidal structure, the interbanding of almost colourless and red ferrite stained portions being very well marked. Ferrite is more or less abundant in the base of all the sections, and is usually disseminated generally through it, sometimes assuming a minutely dendritic form, and often aggregated into dark brown or nearly black irregular masses, and streaks, which sometimes form a black border to the porphyritic minerals. In those portions of the rock which show fluxion structure the ferrite is arranged in bands alternating with the lighter coloured material of the base, and thus making the evidence of flowage very distinct. Iron pyrites can be distinguished in most of the slides, and in some of them it is very abundant in excessively minute crystals. It occurs in all the various sections of a cube, and is sometimes macroscopic in size. Much of the ferrite in the rock has been derived by decomposition from this mineral. Infiltrated secondary quartz occurs, filling small cracks, and irregular-shaped areas, and also, scattered through the base very minute irregular cavities occur, which are filled with clear quartz, which resembles more the secondary quartz filling the cracks and larger areas than either the porphyritic quartz, or the quartz grains of the devitrified portions of the base. This is no doubt a secondary product, and is similar to the "infiltrated network quartz," described by Irving as being present in the bases of the porphyries and felsites of the Lake Superior region of North America.* It is not very abundant, but it can be recognized more or less in every section. Light, green coloured, fibrous epidote is sometimes present in considerable abundance. The porphyritic ingredients are quartz, felspar, and occasionally hornblende. A few of the porphyritic crystals show the remnants of crystalline edges, having the angles rounded off, while the majority, chiefly the quartzes, are much broken and shattered, showing that after their crystallization their edges and angles have been partially redissolved and many of the crystals cracked, due no doubt to considerable movement having taken place in the still plastic magma. This movement is still further evidenced by the presence of well-marked fluxion structure in some portions of the rock. The prophyritic quartzes occur more abundantly than the felspars. They vary greatly in size from almost microscopic blebs and crystals to macroscopic forms one-eighth of an inch in diameter. In shape there is also great variation, from ill-defined crystalline forms to blebs of most irregular outline, which is often picked out with a dark border of ferrite. The edges of the quartzes are often indented by irregular semi-inclusions of the base, while many of the cracks are filled with the same material. No doubt many of these tubular looking cracks have been channels of ingress for some of those portions of the base which now seem to form isolated areas in the interior of the prophyritic quartzes; but some of these inclusions of the base were probably caught up during the crystallization of the prophyritic quartzes. They invariably present the same partially devitrified structure which is characteristic of the general base. The non-occurrence of inclusions of the base in a vitreous condition in the prophyritic minerals, would, I think, tend to show that the devitrification of the base was not a subsequent result, but that it took place during the cooling of the vitreous glassy magma. Some of the quartzes are wonderfully free from inclosures of any kind, even the most minute, but generally they contain the usual microscopical globular inclusions arranged in minutely beaded strings, and scattered indiscriminately throughout the crystals. A few, included microliths, occur in the form of minute prisms, but they are rare.

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* U. S. Geological Survey (King's), 1883, vol. v. (Monograph on the Copper-bearing Rocks of Lake Superior, by R. D. Irving), p. 100.

The porphyritic felspars are not very abundant, indeed in some sections they are not present at all. They include both orthoclase and plagioclase, and are, as a rule, decidedly crystalline in outline. They are usually rendered somewhat opaque by the presence in them of decomposition products and ferrite. In the plagioclase crystals the striations are still recognisable, because of the arrangement of the opaque material along their planes of cleavage. The largest felspars exceed the largest quartzes in size, but are not nearly so abundant. Very minute lath-shaped crystals of felspar occur scattered through the base, in some sections forming quite a distinctive feature.

In a few cases hornblende enters into the composition of the rock as a porphyritic ingredient. It is of a greenish colour, and is rendered almost opaque by black bands of ferrite. A few clear spots and lines, which show pleochroism in polarized light, are still present in the greenish black mass.

In some slides microscopic hexagonal sections of iron pyrites occur porphyritically developed, although this ingredient is generally in minute crystals scattered through the base.

The first four sections are from M.L. 11, Parish of Castleton, and were cut from specimens taken within a few yards of each other. In No. 8 (Pl. II, fig. 1), the porphyritic quartzes still retain portions of their crystalline edges, although their angles have generally been corroded. They contain numerous isolated inclusions of the base, which are similar in structure to the general base. Large porphyritic felspars are rare, and minute sections of iron pyrites are abundant. A few porphyritic hornblendes are present. In section No. 9 the base contains large numbers of microscopic, lath-shaped crystals of felspar. The quartzes are much shattered, and numerous porphyritic felspars occur. In this and the preceding section there is a peculiar arrangement in the secondary quartz, which fills the larger areas in the base. These areas, and many of the secondary quartz individuals which polarize in the same colours, are included within boundaries which are botryoidal in form. These botryoidal boundaries are well marked from the accumulation on them of ferrite grains. In the former section (Pl. II*a*, fig. 1), minute fibrous-looking radiations pass from these botryoidal outlines into the neighbouring quartz individuals. Beautiful dendritic masses of ferrite occur in the secondary quartz. Nos. 10*a* and 10*b* have a brecciated appearance from being divided up into irregular areas by streaks of ferrite and secondary quartz. Numerous clouded porphyritic felspars, and nearly opaque hornblende forms are present.

Nos. 11*a* (Pl. II*a*, fig. 6), and 11*b* (Pl. II*a*, fig. 2) from M.L. 88, Parish of Castleton, show a decidedly sphærulitic structure. Most of the base is formed of individualized quartz and felspar grains, together with abundant fibrous epidote, which is sometimes radially arranged. Scattered through the base are numerous sphærulites which in some parts are aggregated together so as to form wholly sphærulitic areas. They generally appear, however, dotted over the sections, and have ill-defined more or less irregular outlines. From a darker centre, alternate light and dark radiations pass to the periphery, where they gradually merge into the surrounding base. The porphyritic quartzes are small, the chief porphyritic ingredients being much decomposed and clouded felspars, principally plagioclase. Much infiltrated secondary quartz is present. Nos. 12*a* and 12*b* (Pl. II*a*, fig. 3) from the shaft of the Great Mitchell Extended Mine on M.L. 20, Parish of Castleton, show well-marked fluxion structure, the lines of flowage being made very evident by the arrangement of the base in alternate light and dark bands, which sweep round the porphyritic quartz, hornblende, and felspar crystals in the most graceful curves.

Nos. 13*a* and 13*b*, from the Silver Prince Mine, on M.L. 84, Parish of Castleton, are only exceptional from the enormous abundance of secondary infiltrated quartz of ferrite, and which gives them a distinctly red colour.

Nos. 14*a* and 14*b*, from M.L. 7, Parish of Castleton, show indistinct fluxion structure, which is, however, not nearly so well marked as in Nos. 22*a* and 22*b*. The porphyritic minerals are chiefly quartz and hornblende. Irregular lines of ferrite are abundant, and calcite is present no doubt as a secondary product.

Nos. 15*a* and 15*b* (Pl. II*a*, fig. 4) from the Tonkin Mine, on M.L. 56, Parish of Castleton. These have a reticulated appearance, due to the abundance of ferrite streaks traversing the base, and encircling in a concentric manner the peripheries of the porphyritic quartzes, which are circular in outline. This is probably indistinct fluxion structure. Secondary quartz and ferrite are abundant.

No. 16, from shaft of Silver Queen Mine, on M.L. 45, Parish of Coolamigal. The porphyritic minerals, which are chiefly quartzes, in this and the next section, are just large enough to be seen macroscopically. Both sections show indistinct fluxion structure.

No. 17, from end of drive Silver King Mine, on M.L. 62, Parish of Castleton. Microscopic hexagonal sections of iron pyrites occur one-twentieth of an inch in diameter.

These two last sections present an intermediate structure between the true quartz porphyry and the non-porphyritic felsite, being micro-porphyritic felsites.

The non-porphyritic felsites occur as dykes, traversing the Silurian strata, and are a northern extension of the quartz-porphyry of Township Hill. There is so great a similarity in the minute structure of the various sections that it will be unnecessary to describe each one in detail, so that only those which present variations from the common type will be mentioned. Microscopically they resemble in a great degree the base of the quartz porphyries, consisting of a devitrified microcrystalline aggregate of quartz, felspar, and iron pyrites, together with a non-polarizing material, which is either a glass or a microfelsitic substance. The felspar ingredient is more distinct than is the case in the base of the quartz-porphyries, and is in the form of minute lath-shaped microliths. Iron pyrites accurs abundantly in minute crystals in most of the sections. In Nos. 18*a*, 18*b*, 18*c* (Pl. II*a*, fig. 5), from No. 2 level, Sunny Corner Mine, they are not scattered uniformly through the section; but in some parts are individually larger and more widely apart than in others where they are smaller and closer together. Besides occurring in square sections, singly and in aggregates, they are present in a rod-like form. Many of these aggregates surround minute portions of the microcrystalline felsite in which they are imbedded. This is well seen in No. 19, from M.L. 53, Parish of Castleton. Possibly much of the iron pyrites may be of secondary origin. Ferrite is sometimes very abundant in grains and patches. In No. 20, from No. 4 level, Sunny Corner Mine, it is present lining the cracks, which it sometimes fills. Fluxion structure is present in No. 21*a* and 21*b*, from Sunny Corner Mine. Secondary quartz is generally present filling minute veins and small cavities. No. 19 is quite saturated with secondary quartz, and under polarized light the most prominent feature in the section is the innumerable minute irregular cavities filled with it.

The conclusions that seem to follow from a minute study of these eruptive rocks are, that considerable movements took place in the intruded rock-mass prior to its complete solidification, and subsequent to a partial crystallization of its mineral constituents. These movements are evidenced in different ways in different portions of the rock-mass. At one part we have the shattered porphyritic quartzes, at another the presence of fluidal structure, and at another the rock possesses a brecciated character.

The entire absence of perlitic structure, and the fact that none of the isolated inclusions of the base in the porphyritic quartzes occur in a wholly glassy condition (which would probably be the case if the rock had in the first instance solidified into a glassy rock of the rhyolite type) tend to show, although negative evidence, that the crystallization of the various constituents of the rock took place during its solidification, and that it was not due to a subsequent molecular change in the base of the rock after its solidification in a glassy state. In other words, that the crystallization of the various minerals has been of primary origin, and that the rock is not a devitrified rhyolite.

The contraction which the whole intrusive rock-mass underwent during its solidification was no doubt the primary factor in the formation, along its junction with the sedimentary strata, of the cavities, in which were subsequently deposited the lodestuffs containing the silver ore. There is, however, sufficient stratigraphical evidence to show that these cavities were further enlarged, and other cavities formed by subsequent movements which took place along the junction between the two rocks. But whether the various minerals and metalliferous ores were introduced into these fissures from below during the later movements which caused their enlargement, or whether they were slowly deposited by precipitation from the waters which percolated through the eruptive rock, during its passage taking up in solution the various metals and ores, and redepositing them in the fissures, can only, to a certain extent, be proved by the careful study and comparison of the chemistry of the lodestuff, and the intrusive rock respectively. The only fact observed in this relation is that in some places, particularly in the neighbourhood of the Sunny Corner Mine, the eruptive rock contains the sulphides of the various metals which are present in the lodestuff, filling the fissures close by. The presence of sulphides in such a position may, however, be explained by the fact that they might have been deposited in the decomposed portions of the eruptive rock, by infiltrating water coming from the lodes, bearing the sulphides in solution.

IV.—On the Occurrence of a Coral, intermediate in its Structure, between the Genera *Lonsdaleia* and *Spongophyllum*, in the Upper (?) Palæozoic Rocks of New South Wales: by R. ETHERIDGE, Junr., Palæontologist.

[Plate III.]

THE genus *Lonsdaleia* was established by Prof. McCoy* for a group of Carboniferous Rugose Corals, possessing a peculiar tripartite structure. To use his own words, the corallum is "internally composed of three areas; 1st, a cylindrical, defined, complex axis composed of irregularly blended vesicular plates; 2nd, a cylindrical, defined area of strong, vertical, radiating lamellæ, connected by thin, transverse dissepiments, only visible in the vertical section; 3rd, a wide, largely cellular outer zone between the vertical lamellæ, and the external wall of the stem, composed of much-curved vesicular plates extending obliquely upwards and outwards." But to speak in more recent terminology, the "corallum is compound, fasciculate or astræiform, increasing by calicular gemmation. Each corallite is provided with a distinct wall; and an inner mural investment is usually developed. The centre of the visceral chamber is occupied by a very large, somewhat cylindrical columella, formed of twisted lamellæ. A well-developed tabulate area of close-set tabulæ, surrounded by an exterior vesicular zone of large-sized vesicles. The septa are present in the central area, most of them falling short of the columella; but they are not continued through the peripheral vesicular zone to the outer wall.†

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* Annals Mag, Nat. Hist. 1849, iii, p 11.
† Thompson and Nicholson. Annals Mag. Nat. Hist. 1876, xvii, p. 300.

The corallum is always compound, and either astræiform, or in some degree fasciculate. The anatomy of the genus has been fully worked out by Messrs. Thomson and Nicholson, and by Messrs. Waagen and Wentzel,* and from their combined writings an excellent idea of its structre can be obtained.

Lonsdaleia is much restricted in its geological range, "not having been hitherto found to transcend the limits of the Carboniferous rocks." The object of the present paper is to describe a rather aberrant form, the first even provisional evidence of the genus, yet found in Australia,† or, on the other hand, if it be not intermediate between this and *Spongophyllum.* The rocks in which the specimens were obtained are certainly older than Carboniferous—they may perhaps be Devonian; but as no definite geological examination of the district has yet been made, and the geology is said to be much complicated by metamorphic action, the exact horizon must at present remain an open question. It is, however, interesting to note that the probable lower stratigraphical position of this coral is accompanied by a marked modification of structure to that of those found in higher rocks.

Spongophyllum, on the contrary was established by Messrs. Edwards and Haime‡ for a massive and astræiform Devonian coral, in which the corallites are prismatic, and united together by their external walls, but without internal walls or columella. The septa are numerous, very thin, and more or less lost in the vesicular tissue, which nearly fills the visceral chambers. The centre of the latter is occupied by horizontal tabulæ. Recently, however, the characters of *Spongophyllum* have been much enlarged by Dr. Clemens Schlüter, and it is in this sense that the Australian coral approaches the genus.§

In the present instance we are dealing with a coral possessing the typical features of *Lonsdaleia,* except that each corallite seems to be practically devoid of a columella, whether formed of twisted lamellæ or styliform. Unlike the genus *Thysanophyllum,*‖ however, the place of the columella is not taken by a well-marked tabulate area, but the septa merely meet in the centre, or at the most hardly intermingle with one another.

In the present species which it is proposed to provisionally place in *Lonsdaleia,* and call *L? (Spongophyllum) bipartita,* the corallum is massive and astræiform, probaly forming large hemispherical masses, and is highly silicified. The growth of the coral is fairly uniform, although a few irregularities occur here and there. In general appearance it corresponds with such species as *L. floriformis,* Fleming, sp., amongst British forms; *L. papillata,* Fischer, sp., representing the Russian species, and to some extent *L. salinaria,* W. and W., of the Salt Range Series in India.

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* Pal. Indica (Salt Range fossils), 1885, ser. xiii, fas. 1, No. 6, p. 892.

† In the Catalogue of Australian Fossils (8vo. Cambridge, 1878), p. 37, I, by a pure oversight, referred McCoy's *Strombodes australis* to the genus *Lonsdaleia.* This is an error.

‡ Archiv. Mus. Hist. Nat. Paris, 1851, v. p. 425.

§ Ueber einige Anthozoen des Devon. *Verhandl. Naturhist. Vereines Preuss. Rheinlande u. Westfalens,* 1881, xxxviii, heft, 2, p. 189.

‖ Nicholson and Thomson, Proc. R. Soc. Edinb., 1876, ix, p. 149.

The corallites are polygonal in outline (pentagonal, quadrangular, or hexagonal), very unequal in size, and firmly united by their walls. They are surrounded by a thin and pellicle-like epitheca, bearing broad longitudinal sub-angular riblets, and distant transverse accretion ridges. The largest corallite observed possessed a diameter of fifteen m.m., but the mean appears to be ten m.m. The outer walls are distinctly developed, but thin, simple, and somewhat flexuous, and at the upper surface of the corallum project above the general outline of the latter. The calices are deep and infundibuliform, the peripheral surface being very oblique, and the visceral chamber deeply excavated.

In a transverse section (Pl. III, fig. 5) the exterior vesicular zone is very well marked, and usually of great width. The tissue composing it consists of large convex vesicles, rather flattened and much elongated in the direction of their growth, often presenting a pustulate appearance and distinctly visible, thus differing from the Russian *L. papillata,* in which the vesicles are smooth and indistinct. The number of rows between the outer wall and the inner mural investment varies, but the usual number is six. In two or three instances the septa approach the outer wall; but in other cases, and, in fact, in an overpowering majority of corallites, there is a large development of vesicular tissue, especially in the angles of the corallites. The inner mural investment, which usually forms the line of demarcation between the outer vesicular zone and the septal area in most species of *Lonsdaleia,* is very irregularly developed. In some instances, but not in the generality of the corallites, it is distinctly visible, but usually lacks the festoon or scalloped margin so characteristic of it in most of the British Carboniferous species.

The septal, or what would be usually called the intermediate area, McCoy's second area of vertical lamellæ, is of medium size, the septa starting in an irregular and ill-defined manner from the distal row of vesicular plates. They number from eighteen to twenty, and are all primary, careful examination having failed to detect the presence of intermediate and smaller radii. The septa are connected by irregularly placed and close-set tabulæ, but owing to the oblique direction of growth of the latter, they give rise when cut in cross-section to the appearance of dissepiments as if dividing the interseptal spaces into loculi. That this is not the case, however, is amply proved by vertical sections, although from their oblique direction the appearance of these tabulæ is very deceptive. The septa themselves are simple, fairly direct in their course, although here and there a little curved.

There is no columella or "complex axis" strictly speaking, but the surfaces of none of our specimens is sufficienlty perfect to show the natural condition of the septal area at its superior termination. But in a horizontal section (Pl. III, fig. 5) it becomes evident that the distal ends of some of the septa are very loosely twisted, or even only commingled, and hardly even united by any transverse plates, so that a middle or columella zone can hardly be said to exist in this species. There certainly is no columella in the sense of *L. floriformis*, Flem., sp., *L. Bronni*, Ed. & H., or *L. papillata*, Fischer, and others.

More often than not the whole of the septa have been removed from the corallites by ordinary disintegration, leaving the centre as a pipe or circular hollow (Pl. III, fig. 2), on the sides of which the vertical fractured edges of the septa are quite visible. But in some cases the septal zone is preserved, when the want either of a simple or "complex" axis is quite apparent.

In a vertical section prepared for the microscope (Pl. III, figs. 3 and 4), the outer wall is very clearly shown as a thin white line. Equally plain is the vesicular outer zone, with its large vesicles obliquely placed in the direction of the coral's growth. It is against the innermost tier of these that the proximal ends of the septa lie, and in this case the "inner mural investment" becomes more apparent. The vesicles spring at first almost vertically from this line, and then curve outwards, overlapping one another, to the external wall. The interseptal tabulæ are equally well shown in a vertical section, but their oblique direction has already been commented on.

The rudimentary state of the columella, or "complex axis" at once separates *L. ? bipartita* from the European and Indian species. In the former and some of the latter, the columella is well developed. But in those Indian species in which this structure is defective, its place is taken by a true tabulated area, thus showing a departure to the genus *Thysanophyllum*, Nicholson and Thomson. This is "related to the genus *Lonsdaleia* . . . in the general form of the corallum, in the presence of an exterior vesicular zone of large cells, and in the possession of septa which have no connection with the outer wall. It is distinguished, however, by the fact that there is no true columella, and there is always a conspicuous central tabulate area uncovered, and exposed to view in the former; whilst in the latter, the centre of the calicular cavity is occupied by a prominent boss, and by the possession of a median columellarian line, which extends from the superior to the inferior extremity of the corallum, and is surrounded by convex vesicular tissue."

Our coral agrees with *Spongophyllum* in the highly vesicular or cystoid nature of the corallites, strongly resembling in this respect, *S. semiseptatum*, Schlüter, *S. elongatum*, Schlüter, and *S. Kunthi*, Schlüter.* It also resembles the last-named in its mode of growth. There is a further likeness in the absence of a columella, the delicate nature of the septa, and the method in which these advance to the centre of the corallites without twisting or uniting, as seen in *Spongophyllum elongatum*, Schlüter. On the other hand the new form has much more delicate but more distinct external walls than the species quoted above; there is a modified inner wall or "inner mural investment," and the septa are laterally united by a much larger quantity of dissepimental tissue than is found in *Spongophyllum.* Finally, in a vertical section of the latter there is not the same definite evidence of the septal zone that occurs in *Lonsdaleia* and our species. It must, however, be borne in mind that Schlüter's species do not in every way correspond with Edwards and Haime's type of their genus, viz., *Spongophyllum Sedgwickii,** any more than does *L. ? (Spongophyllum ?) bipartita.* As interpreted by Schlüter, *Spongophyllum* closely approaches *Endophyllum,* with which, indeed, he appears in some measure to unite it. Now, it is manifest that in our *Lonsdaleia ? bipartita,* we have a form intermediate between *Lonsdaleia* proper, *Spongophyllum,* and to some extent *Thysanophyllum.* Like the latter, it lacks a columella; but unlike Nicholson and Thomson's genus, it does not possess a "central tabulate area uncovered and exposed to view." It is interesting to note, in conclusion, that even Messrs. Edwards and Haime remark on the resemblance of the vesicular zone of *Spongophyllum* to that of *Lonsdaleia.*†

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* Verhandl. Naturhist. Vereines preuss. Rheinlande u. Westfalens, 1881, xxxviii, heft 2, t. 5, f. 1, t. 7, f. 1 and 5.

In the meantime, and until additional material is available for further study, I shall content myself by provisionally placing the present species in *Lonsdaleia.* It would have been an advantage to compare our fossil with Rominger's genus *Vesicularia,* but his work on the Michegan Corals is not available.

The specimens are from the Hume Wood Lead Mine, near Yass, and were presented to the Mining and Geological Museum by Mr. R. A. Barber.

V.—On the Occurrence of Tellurium in combination with Bismuth, from Norongo, near Captain's Flat, N.S.W.: by JOHN C. H. MINGAYE, F.C.S., Analyst and Assayer.

OBSERVING a peculiar reaction, which took place on the fusion of a supposed bismuth ore in cyanide of potassium for the estimation of the percentage of metallic bismuth, I undertook the following investigation as to the cause of the same.

On fusing the minerals the bismuth was left in the metallic state, the cyanide giving a rich purple colour, which deposited a black metallic powder on standing, the solution losing its colour.

As this reaction is peculiar to Tellurium I was induced to test for that element with the result that a large quantity was found present.

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* Mon. Brit. Dev. Corals, 1853, t. 56, f. 2 a-e.
† Archiv. Mus. Hist. Nat., Paris, 1851, v., p. 425.

On treating some of the metallic powder with concentrated sulphuric acid it at once gave a purpled coloured solution, a characteristic test for tellurium, and it also answered to all other tests given for that metalloid.

The mineral was discovered at Norongo, about eight miles south of Captain's Flat, in a gossan lode about sixteen feet wide, through which runs the vein containing the mineral, the latter being six inches in width, and occurring at a depth of about two feet from the surface.

Three samples were received for assay, which I believe to be bulk samples, and found to yield as follows:—

No. 1.

Metallic Bismuth	16·90 per cent.
Tellurium	7·04 per cent.

Fine silver at the rate of 2oz. 3dwt. 13gr. per ton.
,, gold ,, 3dwt. 6gr. per ton.

No. 2.

Metallic Bismuth	27·88 per cent.
Tellurium	10·42 per cent.

No gold or silver present.

No. 3.

Tellurium	19.3 per cent.

The mineral was associated with an earthy gossan, was steel-grey in colour, crystalline, and with a bright metallic lustre.

Through the kindness of Mr. R. Price I was supplied with specimens showing this mineral freely, as also other minerals, which I shall describe further on.

After much trouble I succeeded in detaching from the matrix sufficient of the mineral for analysis, and found it to be Tetradymite, or Telluric-Bismuth Ore, $Bi_2 Te_2 S$. An analysis gave as follows:—

Tetradymite (or Bismuth Telluride).

Metallic Bismuth	59·66
Tellurium	33·16
Selenium	...
Sulphur	4·54
Iron	·42[*]
Silica	·40[*]
	98.18

The above analysis corresponds with the formula given for the compound containing sulphur, $Bi_2 Te_2 S$. The Sp. Gr. is 7·381.

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[*] Impurities.

Before the blow-pipe the mineral easily melted, coating the charcoal with a yellow and white incrustation, also giving a greenish-blue colour to the flame.

Telluric-Bismuth,[*] or Tetradymite, is stated to have been found in Virginia, Georgia, North Carolina, Cumberland (England), and Brazil, the tellurium sometimes being replaced by sulphur and selenium. The Sp. Gr. is given at 7·2 to 7·9, hardness, 1·2.

The Geological Surveyor-in-Charge, Mr. C. S. Wilkinson, drew my attention to a claret-red coloured mineral, which in places coated the Tetradymite. The mineral was found to contain tellurium, bismuth, iron, and water, and is a variety of Montanite.

Montanite, or bismuth tellurate, of a yellow colour, is often found associated with tetradymite, formed through the oxidation of that mineral, and is in reality a pseudomorph of the latter on which it forms a coating.

On examining a large quantity of specimens pieces were obtained which showed this mineral in a fair quantity, and from these I succeeded in detaching sufficient for a quantitative analysis.

The analysis gave as follows :—

Bismuth oxide (Bi_2O_3)	50·68
Tellurous ,, (TeO_3)	27·65
Iron ,, (Fe_2O_3)	14·38
Water	6·16
Gangue	1·00
	99·87

Before the blow-pipe the mineral gave the reactions for bismuth and tellurium, also giving the flame a greenish-blue colour. It was soluble in hydrochlorid acid.

A mean of several experiments gives the Sp. Gr. at 3·789. This brownish-red mineral is, as the analysis shows, a new variety of Montanite, and is in Mr. T. W. E. David's opinion pseudomorphous after iron pyrites.

In Professor Liversidge's work entitled "Minerals of New South Wales, &c.,"[†] tellurium is reported to occur at Bingera, County of Murchison; but no evidence is given in support of this statement.

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[*] Watt's Dict. Chemistry, 1883, vol. v.

[†] 8vo., Sydney, 1888.

VI.—Description of the Physical Characters of Telluric-Bismuth Ores from Norongo, near Captain's Flat, New South Wales: by T. W. E. DAVID, B.A., F.G.S., Geological Surveyor.

THE specimens of Telluric-Bismuth Ores forwarded for examination from Norongo, near Captain's Flat, consist of lumps of irregular shape, from one inch to nine inches in diameter.

They are associated with an earthy, somewhat cellular gossan of a reddish-brown colour, and consisting of red and brown ferruginous earth, traversed by numerous thin veins of limonite, the secondary origin of which is evident from its stalactitic structure in places, and from the fact that it forms the lining of old cavities.

Small scales of a pale bronze grey micaceous mineral are plentifully distributed through the ochreous earth. They are much decomposed, and upon slight pressure fall into an ochreous powder. A little original quartz, showing cubical cavities, probably resulting from the decomposition of iron pyrites, occurs in the gossan in isolated patches.

The lumps of Telluric-Bismuth enclosed in the gossan show, on freshly-broken surfaces, a general concentric structure, due to the tetradymite having been incrusted with successive coats of decomposition minerals.

The outermost coat, from one-eighth to one-quarter of an inch thick is an earthy mineral the colour of yellow ochre, inclining to orange in places, and showing cubical cavities. Next beneath this telluri-bismuthic ochre is a layer of greenish yellow Montanite, having a somewhat streaky structure. In the second layer, and occupying former cubical cavities, are spots of dark brownish red montanite, from one-eighth to half-an-inch in diameter.

Next beneath the second layer, and forming the nucleus of a lump is a granular crystalline steel grey mass of tetradymite.

The minerals in these ores may, therefore, be classed as follows:—

(1.) Tetradymite.

(2.) Montanite
  (*a*) Pale yellow variety.
  (*b*) Ferruginous dark brownish red variety.

(3) Telluri-bismuthic ochre.

The two first minerals may be further described as follows:—

1. TETRADYMITE occurs in granular crystalline masses, of a steel grey colour and bright metallic lustre.

Under the microscope the crystals are seen to have a very perfect basal cleavage, so that the mineral splits readily into very thin laminæ, over one hundred being visible in one crystal within a space of one-twentieth of an inch. Most of the crystals appear to be tabular. The orientation of the crystals in each mass is tolerably uniform, and the planes of basal cleavage lying in consequence principally in one line, the mass has a tendency to split readily along these planes, which accounts for the streaky appearance of the montanite surrounding the tetradymite.

The *hardness* is about 1¾, the mineral being unaffected by talc, easily scratched with calcite, and difficulty scratched with selenite. The laminæ are flexible.

The *streak* is black and shining, much like that of graphite.

2. MONTANITE *(a), Pale greenish-yellow variety.*

This mineral encrusts the tetradymite, and does not show any crystalline structure. Green tints are observable in this variety wherever the particles of half-decomposed tetradymite become abundant, the green being due to the steel-grey tetradymite showing through the yellow coating of montanite.

The *lustre* varies from dull earthy to waxy. The *hardness* is about 1½.

(b.) Ferruginous dark brownish red variety.

This variety occurs in cubical pseudomorphs, single or aggregated, and ⅛ inch in diameter.

The *colour* is dark brownish red, excepting on thin edges, where the mineral is semi-transparent and of a deep claret colour. The *streak* is of a red ochreous colour. The mineral is brittle, and has an uneven, irregular fracture.

The *hardness* is about 3, but appears to vary considerably in the different specimens, as calcite will just scratch some, but is itself scratched by others. From the roughly cubical shape of this mineral, taken into conjunction with the existence of numerous cubical cavities, like those left after the decomposition of iron pyrites in the telluri-bismuthic ochre and gossan, it appears to me highly probable that this variety of montanite is psuedomorphous after iron pyrites, and the analysis proves that the dark brownish red colour is due to the combination of iron with the montanite.

It may therefore be described provisionally as ferruginous variety of montanite, pseudomorphous after iron pyrites.

VII.—Sketch of Columnar Basalt on the Horton River, near Lindsay Station.

[Plate IV.]

THE accompanying sketch of the Horton River Falls, situated about one and a half miles from the homestead of the Messrs. Sawers and Wilson's Lindsay Station, was made by Mr. Henry W. Powell, Forest Ranger, Gunnedah, who has forwarded it to the Department with the following interesting description.

The Horton River, for some distance above the falls, runs over the tops of basaltic columns, giving the bed of the stream and the bank on the east side the appearance of a large pavement. The stream then empties itself into a basin about fifty yards across and twenty or thirty long, in the shape of a horseshoe, the sides of which are formed of these columns.

The water pours over in several jets between the different columns, which measure twenty feet in height. The columns are mostly five-sided, though some have four and some six sides, and measure five feet and upwards in diameter; they are horizontally jointed, and appear as though they had been built up in courses.

Part of the basin is heaped up with fragments of these columns which have a smooth surface where the joint has been broken.

PLATE I.

Fig. 1. Longitudinal section of cliff at Long Bay, showing the Hawkesbury and Post Tertiary strata at the point where the Human Remains were found.

Fig. 2. Vertical or cross section of the same.

Fig. 3. The Skeleton lying in the position in which it was found, with the implements and shells *in situ.*

Fig. 4. The larger of the two skinning knives; side view.

Fig. 5. Cross section of Fig. 4.

Fig. 6. The smaller of the two implements; side view.

Fig. 7. Cross section of Fig. 6.

Figs. 1, 2, and 3 are on a scale of eight feet to one inch.

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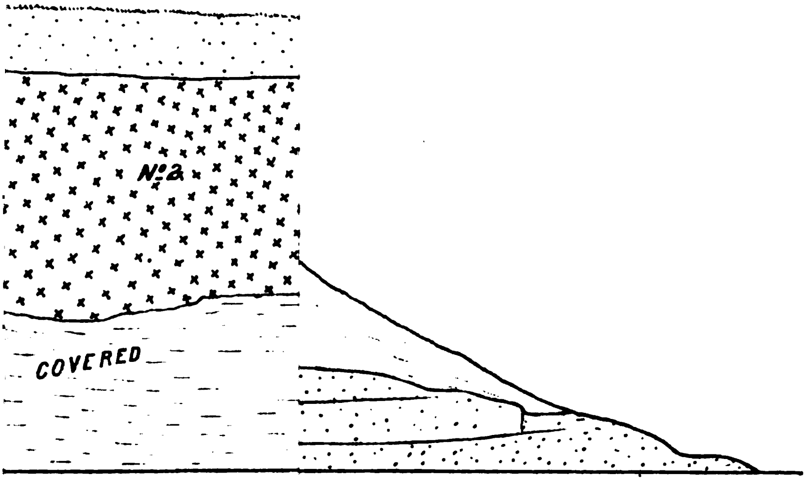

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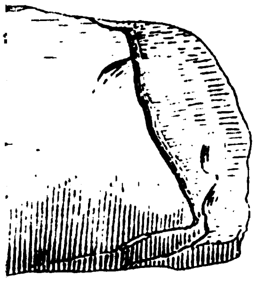

15 16 feet

pumice.

aly and very hard at top of bed.

e with intercalated bed of shale.

High water level

(11a 234a)

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PLATE II.

Geological Sketch-Map of Sunny Corner, county of Roxburgh, by Mr. C. S. Wilkinson, Geological Surveyor-in-Charge, and Mr. W. Anderson, Geological Surveyor. Scale—forty chains to one inch. [Extracted from the *Ann. Report Dept. Mines, N. S. Wales, for* 1886 [1887], *App. E.*]

PLATE II

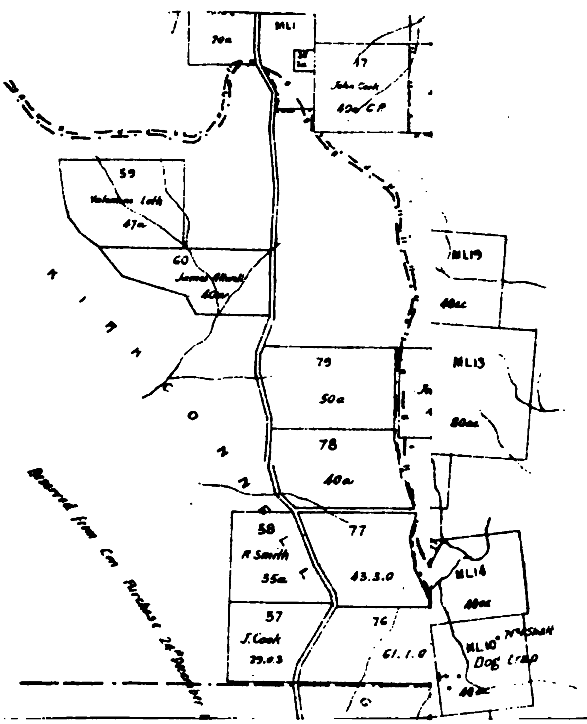

70a
ML1
47
John Cook
40a C.P.
59
47a
60
40a
ML19
40ac
79
50a
78
40a
ML13
80ac
58
R Smith
35a
77
43.3.0
57
J. Cook
39.0.3
76
61.1.0
ML14
40ac
ML10
Nº Shaft
Dog trap
40ac
Reserved from Con Purchase 24 December

PLATE II*a*.

Fig. 1. Quartz-porphyry from M.L. 11, Parish of Castleton (slide No. 8), showing secondary quartz filling a cavity in the base whose outline assumes a botryoidal form, from which numerous fibrous radiations pass into the quartz.

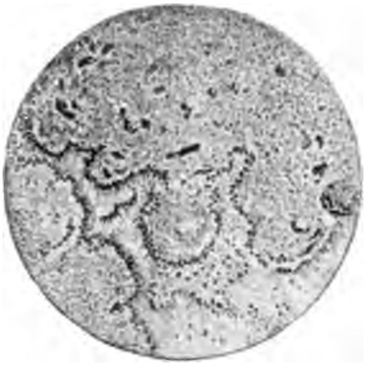
Fig. 2. Sphærulitic quartz-porphyry from M.L. 88, Parish of Castleton (slide No. 11*b*), showing a sphærulite in polarised light.

Fig. 3. Quartz-porphyry from Great Mitchell Extended Mine, Parish of Castleton (slide No. 12*b*), showing fluxion structure.

Fig. 4. Quartz-porphyry from Tonkin Mine, Parish of Castleton (slide No. 15*b*), showing a corroded porphyritic quartz.

Fig. 5. Non-porphyritic felsite from No. 2 level, Sunny Corner Mine, Parish of Castleton (slide No. 18*c*), showing the mode of occurrence of iron pyrites in the non-porphyritic felsites.

Fig. 6. Sphærulitic quartz-porphyry from M.L. 88, Parish of Castleton (slide No. 11*a*), showing the porphyritic ingredients, quartz and felspar, and epidote in the base.



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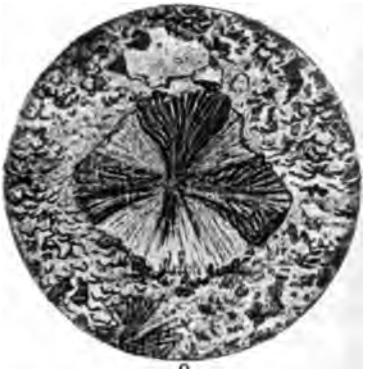

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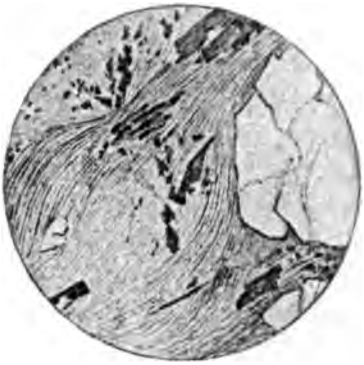

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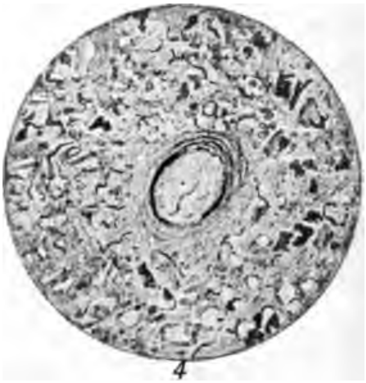

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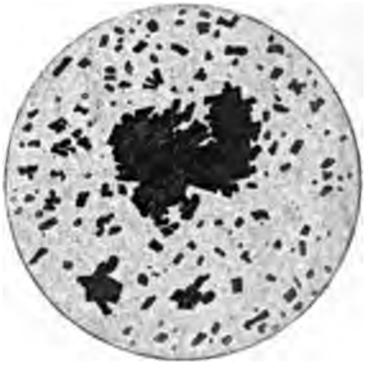

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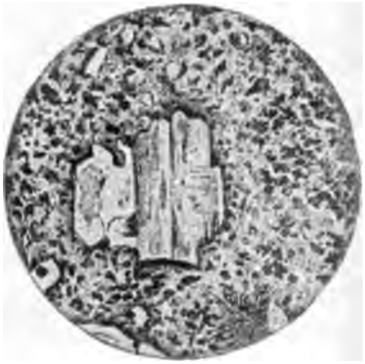

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PLATE III.

Lonsdaleia ? bipartita, ***sp. nov.***

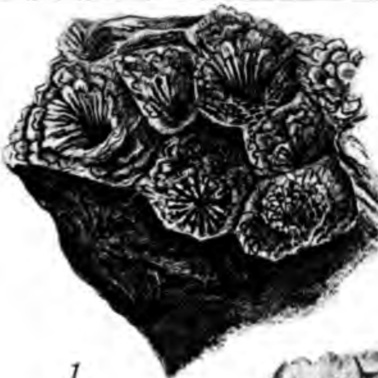
Fig. 1. Portion of the corallum, seen from above, showing the deep calices, vesicular zone, septa, &c. x 1½.

Fig. 2. Longitudinal view of three corallites, those on the right showing the external appearance, and that on the left in section, with the septa and vesicular plates visible. x 1½.

Fig. 3. Vertical section of a corallite prepared for the microscope, showing the boundary walls and vesicles. x 3.
(N.B.—This section has been inadvertently turned upside-down.)

Fig. 4. Vertical section of another corallite from a polished hand specimen, showing the boundary walls of the corallites, the vesicular zone on each side, and the central septal area with the broken vertical lamellæ, and the small horizontal tabulæ. x 1½.

Fig. 5. Horizontal section prepared for the microscope with two corallites, showing the large vesicles of the outer area and the septa of the inner zone which do not meet in the centre. x 3.



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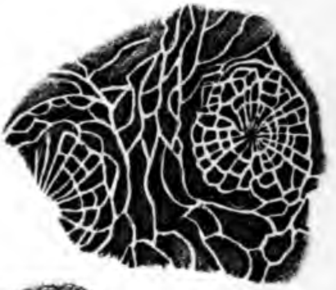

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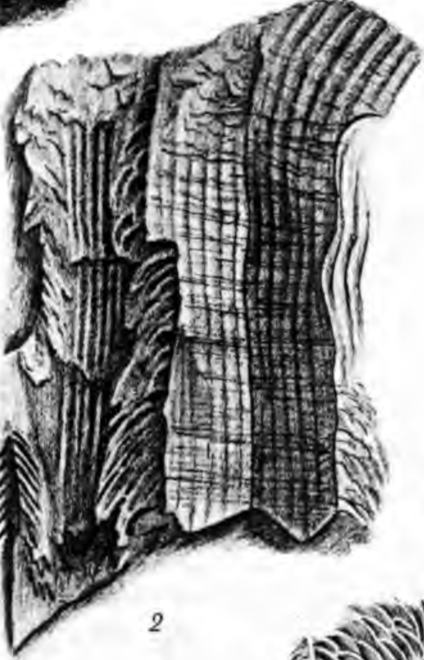

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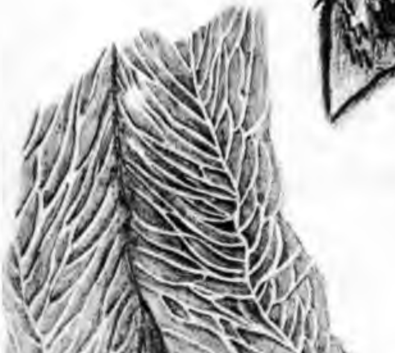

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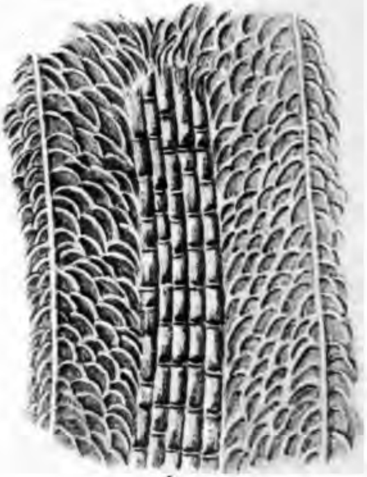

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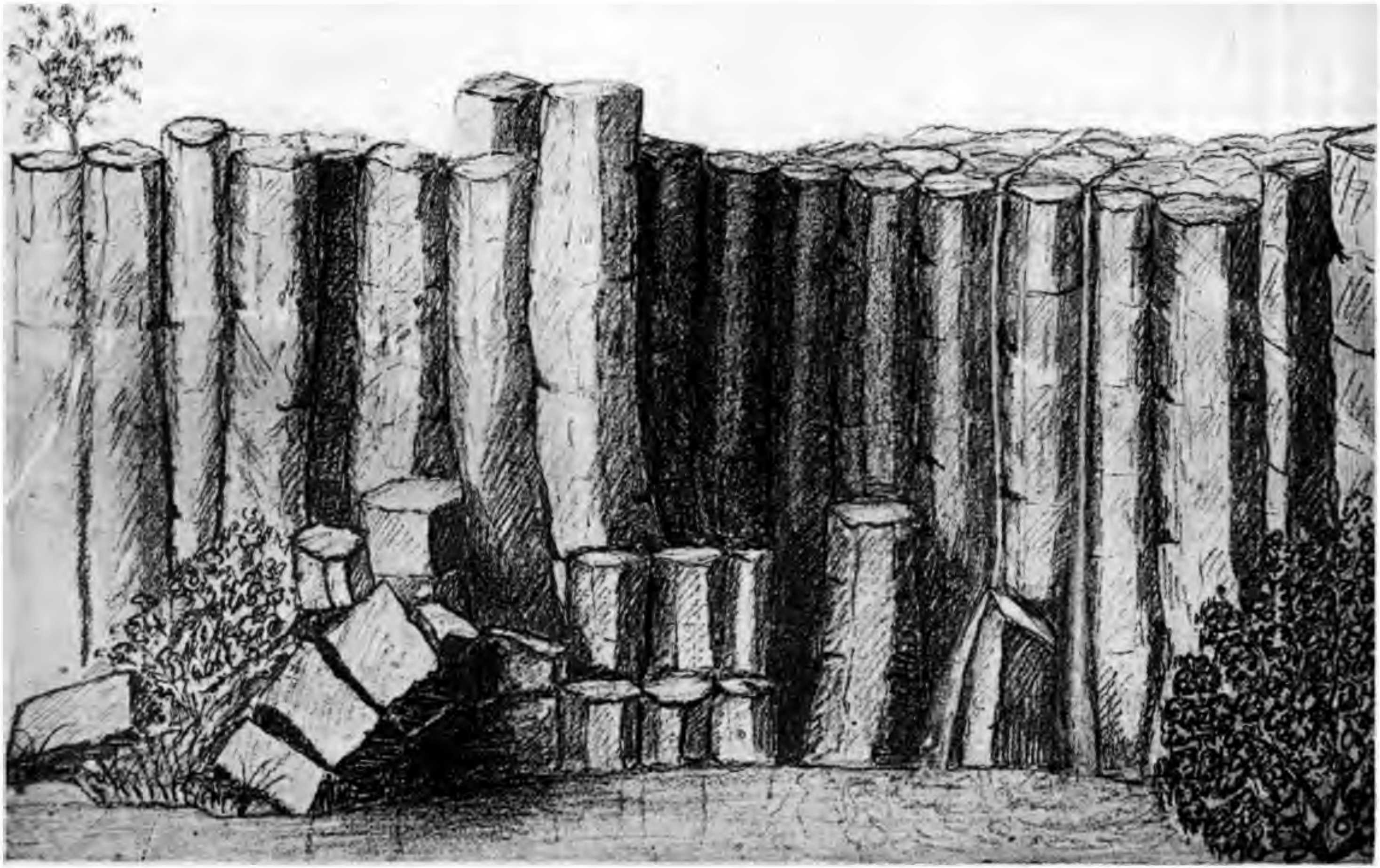
PLATE IV.

Sketch of the Horton River Falls, near Messrs. Sawers and Wilson's Lindsay Station, showing basaltic columns forming the bank and bed of the stream: by Mr. H. W. Powell, Forest Ranger.

PLATE IV.



CATALOGUE OF MINING MAPS

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1st JANUARY, 1889.

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ALBERT MINING DISTRICT.

or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
	Yancowinna	Thackaringa.	Mount Gipps	Yancowinna	Silverton.
	do	"The Pinnacles."	Muerkalo	do	do Mount Gipps.
	Farnell	Corona.	Nadallu	do	do
ey	Yancowinna	Silverton.	Purnamoota	do	do
	do	do	Picton	do	do Broken Hill.
	do	Silverton, Round Hill.	Robe	do	do Purnamoota.
	Farnell	Corona.	Stephen	do	do
gero	do	do	Soudan	do	do
ow	do	Poolamacca.	Sebastopol	do	do Rockwell Paddock.
	do	Corona.	Tara	do	do Fraser's Nob.
	Yancowinna	Silverton.	Umberumberka	do	do
Gap (see Giles)	Farnell		Waukeme	do	do
	do	Fowler's Gap.	Yancowinna	do	do
	Yancowinna	Silverton.			

BATHURST MINING DISTRICT.

or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
)	Westmoreland	Wiseman's Creek.	Jocelyn	Westmoreland	Wiseman's Creek.
	do		Langdale	do	do
	Roxburgh	Sunny Corner.	Lennox	Bathurst	Ophir Gold-field.
al (h)	do	do	Lewis	do	do
mber	do	do	Mulgunnia	Georgiana	Mulgunnia Gold-field.
	do	Clear Creek and Kirkconnell Gold-field.	Oberon	Westmoreland	Oberon Gold-field.
			Tuena	Georgiana	Abercrombie Gold-field.
	do	Sunny Corner.	Worcester	Bathurst	Ophir Gold-field.
	Georgiana	Junction Point, Tuena Creek, and Mackdale Gold-fields.	do	do	do
				(Survey Office litho. adopted.)	

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
	Gresham	Boyd or Little River Gold-field. (Survey Office litho. adopted.)

HUNTER AND MACLEAY MINING DISTRICT.

, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
	Gloucester	Barrington Gold-field.	Craven	Gloucester	Barrington Gold-field.

LACHLAN MINING DISTRICT.

, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
ery.	Bland	Temora Gold-field.	Parkes	Ashburnham	Billabong Gold-field.
r	Ashburnham	Billabong Gold-field.	Young	Monteagle	Burrangong Gold-field.

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Gulgong (a)	Phillip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field.
Guntawang (b)	do	do	Wyaldra	Phillip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Arvid	Gough	Vegetable Creek	Land's End (o)	Gough	Emmaville Gold-field.
[illegible]	Clive	do	Mole (p)	do	do
[illegible] (a)	Gough	do	Maryland (q)	Buller	Wilson's Downfall.
Bookookoorara (b)	Buller	Wilson's Downfall.	Marsh (r)	do	do
Bates (c)	Clive		Paradise North (s)	Gough	Emmaville Gold-field.
[illegible] (d)	do		Purvis (t)	Clive	
[illegible] (e)	do		[illegible] (u)	Buller	Wilson's Downfall.
[illegible] (f)	do		Rockvale (w)	Clive	Emmaville Gold-field.
Boorook	Buller	Boorook Gold-field.	[illegible] (x)	do	do
Boonoo Boonoo (g)	do	do	Strathbogie	do	do
Curry (h)	do	Wilson's Downfall.	Strathbogie North (y)	do	do
Cullendore (i)	do	do	Scone	do	do
[illegible] (j)	Clive	Emmaville Gold-field.	[illegible]	do	do
[illegible]	Buller	Bald Rock.	[illegible] (a¹)	do	do
[illegible] (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
Fraser (l)	do	Emmaville Gold-field.	[illegible] (b¹)	Buller	Wilson's Downfall.
Flagstone	do	do	Wellington Vale	Gough	Emmaville Gold-field.
Highland Home	do	do	Wellington North (c¹)	do	do
Hamilton (m)	do	do	[illegible] (d¹)	Buller	Wilson's Downfall.
Haystack (n)	do	Vegetable Creek.	[illegible]	[illegible]	

PEEL AND URALLA MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
[illegible]	Hardinge	Cope's Creek.	[illegible]	Darling	[illegible]
[illegible] (a)	Murchison	Bingara Diamond-field.	[illegible] (k)	Murchison	Bingara Gold-field.
Bingara (b)	do	do	[illegible]	Hardinge	Cope's Creek.
Boyd (c)	Gough		Mitchell (l)	Gough	
[illegible] (d)	do		[illegible] (m)	Murchison	Bingara Gold-field.
Bald Nob (e)	do		[illegible]	Sandon	Hillgrove.
Clive	do	Cope's Creek.	Nundle	Parry	Peel River Gold-field.
Clare	Hardinge	do	[illegible]	Hardinge	Cope's Creek.
Cope's Creek	do	do	Severn (n)	Gough	
Coventry	Clarke		[illegible] (o)	do	
[illegible]	Sandon	Hillgrove.	[illegible] (p)	Gresham	Mitchell River.
Darby	Hardinge	Cope's Creek.	Scone and Strathbogie	(See New England Mining District.)	
Dungowan (f)	Parry	Peel River Gold-field.			
Dinoga (g)	Murchison	Bingara Gold-field.			
Derra Derra (h)	do	do Diamond-field.	Tingha	Hardinge	Cope's Creek.
[illegible] (i)	do	do do	[illegible] (q)	Gresham	Mitchell River.
[illegible]	Gough	Cope's Creek.	Wood's Reef	Darling	[illegible] Gold-field.
[illegible]	Inglis		Wellington Vale	(See New England Mining District.)	
Hall (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nerrimunga	Argyle	Nerrimunga Gold-field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
[illegible] (a)	Wellington	Hill End and Tambaroora.	[illegible] (b)	Wellington	Hill End and Tambaroora
Tambaroora	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Adelong (a)	Wynyard	Adelong Gold-field.	[illegible] (e)	Wynyard	Adelong Gold-field.
[illegible] (b)	Murray	[illegible] Flat.	[illegible] (f)	do	do
[illegible] (c)	do	do	[illegible] (g)	do	do
[illegible] (d)	Wynyard	Adelong Gold-field.	Wondalga (h)	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. I, PART II.

1889.

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GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY.

(1.) MAPS.

Map showing Mineral Areas of New South Wales. Scale, 8 miles to 1 inch.
Do do do Scale, 50 miles to 1 inch.
Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
Do do do do Scale, 22 miles to 1 inch.
Geological Map of the Districts of Hartley, Bowenfells, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.
Geological Map of Hill End and Tambaroora, by E. F. Pittman, Geological Surveyor.
Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 58 chains to 1 inch.
Index Map of the Vegetable Creek Tin fields, by T. W. E. David, B.A., F.G.S. Scale, 80 chains to 1 inch.
Geological Map of the Forest Reefs District, by H. Y. L. Brown, Geological Surveyor.
Map of the Silver-mining Country, Barrier Ranges, by C. S. Wilkinson, L.S., F.G.S.
Vertical Sections of New South Wales Upper Coal Measures, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Diagrams showing the Thickness, Character, and Portion mined out of Coal-seams in the Coal Measures of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Plans showing the Outcrop, Thickness, and Dip of the Coal-seams in the Northern, Southern, and Western Coal-mining Districts of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal fields.

(2.) PUBLICATIONS.

The Mining Act of 1884, with Regulations.
Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.

Mineral Products of New South Wales, 1882, containing:

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

Mineral Products of New South Wales, 2nd Edition, 1886, containing:--

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.

Memoirs of the Geological Survey of New South Wales.

Geology.

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.

Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales; and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)

Records of the Geological Survey of New South Wales.

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DEPARTMENT OF MINES, SYDNEY.

RECORDS
OF THE
GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. 1.] 1889. [Part 2.

VIII.—Notes on the Mineral Resources of New South Wales, as represented at the Melbourne Centennial International Exhibition of 1888; by J. E. Carne, Curator, Mining and Geological Museum, Department of Mines, Sydney.

I.—*Introduction.*

THE Commission appointed to secure the proper representation of New South Wales at the above Exhibition, in accordance with the practice of previous Commissions, requested the Honorable the Minister for Mines to undertake, through his Department, the preparation of a thoroughly representative exhibit of the mineral resources of the Colony; also to classify and prepare all private exhibits of a like nature, and to arrange the whole in the space set apart by the Executive Commissioner as a Mineral Court. This request having been approved, the necessary steps were taken to ensure a display worthy of the reputation already gained by New South Wales as a varied and extensive mineral-producing country.

Having been instructed to devote myself to the work, after inspection of the space set apart for the above purpose, a general plan of arrangement was designed, which, meeting with approval, I was authorized to carry out.

In the following notes I have endeavoured to present a concise account of the exhibits thus brought together and arranged, and whilst avoiding technical descriptions, to furnish such information as could be gleaned from publications of the

Department of Mines and other reliable sources, as to the nature, occurrence, and yield of the deposits from which they were obtained, deeming that this presented in convenient form would be of service and value to those interested in our mineral resources.

II.—General Arrangement of the Court.

I preface the detail description by a brief *resumé* of the general arrangement.

The Mineral Court was situated directly on the right-hand of the Avenue of Nations upon entering from the main or permanent hall. It was nearly square, having a frontage of 110 feet to the above Avenue, by a depth of 106 feet, and embraced an area of 11,660 square feet, being bounded on two sides by main avenues, on another by a wall, and on the remaining side by the wool exhibits of the Colonies. It was very compact, and so situated with regard to surrounding exhibits that its contents were thrown into greater relief by contrast. Upon entering the Avenue of Nations from the Main Hall, the object that arrested the view was the handsome silvered obelisk erected by the Broken Hill Proprietary Company; but the first exhibit was a model of portions of the Jenolan Caves, with an imposing entrance—constructed in imitation of the Grand Arch—prepared by direction of the Executive Commissioner, and planned and admirably carried out by Mr. Noonan. Near the entrance, in an upright glass show-case, was an exhibit of stalactites, stalagmites, and crystals from the same caves, collected and arranged very naturally by the keeper, Mr. J. Wilson, by instructions from the Minister for Mines. The visitor was thus enabled, after viewing man's handiwork in imitation, to turn and view nature's in reality. It is, perhaps, well to state that the beautiful specimens in this case did not represent the spoil of a Vandalism only too common with regard to Nature's treasures, but were the proceeds of explorations of intricate and almost inaccessible holes and passages, impassable to the ordinary visitor.

The next object on the frontage was an octagonal pyramid of copper ingots surmounting a base of copper ores from various mines. Then came the artistic obelisk of the Broken Hill Proprietary above alluded to. It consisted of an octagonal base about eleven feet in diameter and three feet three inches high, faced with rough blocks of stone from the outcrop and from different levels; on this rested eight slanting show-cases containing samples of the various ores—to be described further on—from this height sprang a handsome, ornamented column, capped by a large casting of Atlas supporting the world, reaching to a height of thirty-three feet three inches, with a bulk of 577 cubic feet, and thus representing the total quantity of silver produced by the mine since smelting was begun in May, 1886, to the time of designing in June, 1888, viz.: 5,508,836 ounces, or 166 tons, of fine silver.

Next to this was a huge pile of auriferous quartz from the Kurrajong Gold Mine, Adelong; then a porch, or entrance to the main portion of the Court. Next to this another large pyramid of ore from the White Rock Silver Mine, Fairfield; and then at the extreme northern end of the Court, a massive square-based pyramidal trophy of copper ingots and ore, from the Burraga Mine, about fifty miles from Bathurst.

The Court was divided into bays by lines of supporting pillars, running at right angles from the Avenue of Nations. The first bay on the south was devoted principally to coal and shale exhibits, which were arranged on either side of a broad central passage traversing its length, at the end of this, and opposite to the entrance, was placed a large trophy of coal blocks; on the panels which enclosed the angular spaces of the trophy, were given the names of the principal collieries at work upon the coal seams described on the upright panels at the centre of the angles; at the base of the angular spaces were show-cases containing exhibits of coke. This exhibit was designed primarily to draw attention to the particulars thus displayed.

On the right hand upon entering the bay from the Avenue was a handsome show-case, standing on a raised platform, containing a most attractive exhibit of the products of the Australian Kerosene Oil and Mineral Company's shale, a pile of which was shown at each corner of the platform.

On the wall space, which formed the southern side of this bay, were arranged the mining and geological maps, sections, &c., of the Department of Mines. The next bay, which was entered by the porch before-mentioned, was devoted principally to metalliferous exhibits. Directly upon entering, the visitor was confronted with a massive coal and stone triple archway, spanning the bay at about two-thirds of the depth of the Court from the entrance. The two centre pillars were four feet by four feet by thirteen feet six inches high; and were formed of twelve feet of coal, resting on one foot of sandstone from underneath the coal-seam at Waratah, and capped by six inches of sandstone from the upper beds of the coal series in New South Wales (Hawkesbury Series), the coal being from the Burwood Colliery, near Newcastle, and the latter sandstone from R. Saunders' Pyrmont Quarries, Sydney. The coal pillars represented about the average working thickness of the Borehole seam. The two outer pillars, of the same height and depth, but one foot narrower, were constructed of rough-dressed sandstone, also from Pyrmont Quarries.

The superstructure of the archway bore the following inscription, in silver letters on a black ground:—" Mineral Court of New South Wales."

"Minerals raised in New South Wales to 31st December, 1887—total value, £72,938,124 18s.*

		Quantity	Value. £	s.	d.
Gold		9,885,094·25 oz.	36,863,717	9	1
Silver		2,923,037·62 oz.	1,806,349	0	0
Silver-lead	Metal	13,231 tons 1 cwt. 1 qr.			
	Ore and Regulus	15,894 ,, 14 cwt. 2 qr. 7lb.			
Coal		39,892,861·97 ,,	19,698,831	15	5
Shale		481,252 ,,	1,083,174	5	0
Iron		36,228 ,, 15 cwt. 0 qr. 6 lb.	265,464	14	6
Tin	Ingots	85,078 ,, 6 ,, 0 ,,	7,927,876	0	0
	Ore and Regulus	16,671 ,, 13 ,, 0 ,,			
Copper	Ingots	79,131 ,, 18 ,,	5,163,352	0	0
	Ore and Regulus	3,760 ,, 4 ,, 2 ,,			
Antimony	Metal	475 ,, 13 ,, 1 ,,	67,239	0	0
	Ore and Regulus	25 ,, 4 ,, 0 ,,			
Bismuth		104 ,, 18 ,,	20,575	14	0
Asbestus		25 ,, 4 ,,	488	0	0
Sundry Minerals			41,057	0	0"

Down the centre of this bay ran a broad passage, as far as the Wool Trophy on the east. On either side of it were massive trophies of ores, alternating with show-cases containing hand specimens.

In the portion of the third bay embraced by the Mineral Court, and fronting the east and west avenue, arranged on six stands, and in four cases, was the large and valuable collection of timber specimens, barks, fibres, gums, resins, seeds, etc., exhibited by the Minister for Mines. In this space also was arranged in six show-cases, a collection of fossils from the principal sedimentary formations of the Colony, also exhibited by the Minister for Mines.

In the arrangement of the Court an endeavour was made to place the different groups of ores together; but in some instances this was prevented by the late, or non-arrival of exhibits intended for certain positions, which had to be filled with ores from another group. If, therefore, any exhibits were not as advantageously placed as could be desired, it was owing to late arrival; and it behoves intending exhibitors on such occasions, for the advantage alike of the exhibits and the Court, to dispatch them early.

Exception has been taken to the meagre information on the labels attached to certain exhibits, both as to variety and yield, of the ores forming them; such, in certain cases, was undoubtedly true; but the fault did not rest with those engaged in the work of arrangement. In each case the fullest information was solicited; this particularly refers to occurrence, extent, and yield of the deposits represented. As regards non-classification, it can be reasonably urged that exhibits arriving during the rush of hurried arrangement in the Court, could not be other than roughly classed into groups. Again, the main idea in connection with many exhibits, was massiveness, to separate and classify the different varieties in a large pile of ore would require unreasonable space. In the general collections of different ores exhibited by the Minister for Mines, nearly, if not all, of the varieties could be seen properly classified and arranged. In the following notes and compilations I have endeavoured to remedy the defect as regards the information concerning the nature, occurrence, and yield of the ores exhibited, where no particulars are given none have been available.

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* Compiled from the Annual Report, 1887, of Mr. Harrie Wood, Under Secretary for Mines.

III.—Gold.

Taking the metals in the order of their respective values (of output), gold occupies the premier position,—The weight of gold obtained to the end of 1887 was 9,885,092 ounces, of the value of £36,863,716. Except in some few localities, quartz veins have not been worked to a great depth. The deepest mines in the Colony are at Adelong, where payable quartz has been raised from a depth of over 1,000 feet. Alluvial lands have in some instances been worked to a depth of 200 feet, and there are the strongest indications of deep leads in various parts where no attempt has been made to work them. Gold-mining, as hitherto carried on, has been principally confined to the working of river beds and shallow alluvial claims and deep leads. Extensive areas of country are known to be auriferous, and it is believed that there will be ample scope for the remunerative employment of a large population in both alluvial and quartz mining. The poor success which has often attended the working of quartz veins is largely attributable to ill-judged speculation, inexperience, and the absence of proper ore-separating and other mining appliances.

The approximate area included within the proclaimed gold-fields is 91,800 square miles; but, from the geological formation of the country, it is believed that the area in which payable gold deposits will be found will be greater than that now stated. From some of the reefs at Hill End crushings gave at the rate of from 30 to 2,100 ounces of gold per ton. It is known that much gold passes away in the tailings, and is lost in consequence of the imperfect appliances at present employed for the treatment of auriferous pyrites.

The Minister for Mines had a splendid exhibit of reef and alluvial gold; two specimens of the former, obtained from a depth of 90 feet at the Mother Shipton Reef, Temora, were of special interest, the largest was estimated, by specific gravity test, to contain 258·33 oz. of fine gold in about 60 oz. of white quartz; the other was estimated by the same test to contain 41·53 oz. of gold in about 90 oz. of quartz. The following samples were also worthy of note:—Gold in ferruginous quartz from Solferino; forming a thin vein in quartz from Bingera; in serpentine from Lucknow; in calcite from Ti-tree, Oakey Creek, Barraba District. Particularly noticeable amongst the specimens of alluvial gold was the handsome "Maitland Bar Nugget," obtained from a depth of five feet, at Hargraves, which was estimated by specific gravity test to contain 313·093 oz. of fine gold, of the value of

£1,236 14s. 1d., the gross weight being 344·7 oz. Another nugget from Woods' Flat, near Cowra, weighed 42 oz. 17 dwt. 5 gr., of the value of £168 5s. 5d; one side of this specimen, which has been protected from attrition by a ferruginous clayey covering, presents a nest of crystal facets. Two small nuggets were shown from Trunkey and the Turon. Forty-four samples of alluvial gold from the undermentioned localities were also shown, and the assay report of each sample was given, as supplied by the Royal Mint, Sydney :—

Locality.	Specific gravity.	Loss per cent. in melting.	Assay Report.		Gross value per oz.		
			Gold in 10,000 parts.	Silver in 1,000 parts.	£	s.	d.
Tenterfield	15·89	2·733	·8905	·100	3	13	11
Mudgee	16·89	1·713	·9370	·055	3	18	5
Tibooburra	18·33	·423	·9735	·020	4	2	4
Uralla	17·76	1·215	·9550	·040	4	0	3
Tumbarumba	15·98	2·955	·9460	·045	3	18	1
Bathurst	16·78	2·033	·8865	·080	3	14	0
Forbes	15·47	2·647	·9215	·075	3	16	5
Hill End	16·44	2·663	·9445	·045	3	18	2
Sofala	16·71	1·848	·9265	·070	3	17	5
Kiandra	15·15	3·115	·9240	·070	3	16	3
Nundle	15·00	2·642	·9220	·070	3	16	5
Bingara	14·54	5·137	·8995	·090	3	12	9
Tamworth	15·94	1·716	·9355	·060	3	18	3
Copeland	14·69	3·748	·9000	·090	3	13	10
Nerrigundah	17·75	1·395	·9825	·010	4	2	4
Murrumburrah	17·06	1·906	·9470	·045	3	19	0
Glen Innes	17·19	1·535	·9435	·050	3	19	0
Ironbarks	16·29	2·420	9420	·055	3	18	3
Orange	16·29	2·188	·9290	·065	3	17	5
Windeyer	18·39	·995	·9550	·040	4	0	5
Temora	16·71	2·166	·9575	·030	3	19	7
Rocky River	16·70	1·423	·8760	·115	3	13	9
Adelong	17·18	1·953	·9470	·045	3	19	0
Tambaroora	17·10	1·522	·9335	·060	3	18	3
Braidwood	16·73	2·330	·9455	·045	3	18	7

Mr. M. Isaacsohn, of Nundle, exhibited a number of very beautiful specimens of crystallized gold from Bowling Alley Point, Peel River, some of the gold crystals being associated with clear quartz crystals, both having been deposited from solution in a cavity in the veinstone; the same exhibitor also showed a number of samples of alluvial gold.

Professor Liversidge exhibited interesting specimens of crystallized gold from Gulgong, Louisa Creek, Orange, Lion Reef (Grafton), and Mudgee; moss-gold obtained from mispickel, Lucknow; and gold in calcite, dolomite, serpentine, pyrites, and arsenic.

The Minister for Mines exhibited a collection of auriferous ores, comprising auriferous binary granite, from the 1,050 feet level in the Great Victoria Mine, Adelong; auriferous lode-stuff (gneiss), from the 1,000 feet level, in the same mine; auriferous quartz, with pyrites, from the 770 and 975 feet levels; quartz showing free gold from the Kurrajong Mine, Adelong; lodestuff (binary granite), with free gold and pyrites, from the Challenger Mine.

The following particulars regarding the Great Victoria, the deepest mine in New South Wales, may be of interest; a trial crushing from it was made with a view of proving the claim to a Government reward for a payable reef at depth exceeding 1,000 feet.

"The quartz crushed for the recent trial came from the south shaft, at a depth of about 1,030 feet, which level is equal to 1,067 feet below that of the surface at the North Shaft, as the latter is 37 feet above that of the South Shaft, owing to the slope of the hill. The reef at the deepest level attained, viz., 1,056 feet, presents the same features that it does at the higher levels . . . . it occurs in a dark greenish schist which varies in width from about 2 to 10 feet, and it is bounded on both sides by well defined walls of hard quartzose granite containing black mica The quartz reef is sometimes over 12 inches thick, at others it makes into several veins accompanied by numerous thread-like veins of gold-bearing quartz interlaminated with schist, so that in places nearly the whole width of the schist or channel of the reef is taken out for crushing. Such is the general character of the veinstuff from the surface down to the lowest level. Both the schist and the quartz are highly impregnated with pyrites. Occasionally "horses" of granite make into the schist. The reef is nearly vertical, sometimes underlaying slightly to the east, at others to the west, but the general underlay is easterly; the strike of the reef is N. 10° W." *

The Kurrajong Gold-mining Company, Adelong, exhibited ten tons of auriferous pyritous quartz, in which zincblende occurred sparingly, the stone yielding the best returns where it was present. The remarks quoted from the Report of Mr. C. S. Wilkinson, Government Geologist, on the Great Victoria Mine, in the same field, will apply as regards the general character and features of the reef, equally well to this mine; as also to the Donkey Hill stone from the same locality.

From Fairfield, New England, were shown samples of auriferous ferruginous quartz from Scott's, Rowan's, Carmichael's, Parnell's, Bourke's, Dempsey's, and others' claims; auriferous quartz with zincblende and pyrites from Strous and Party's claim, auriferous lode-stuff with zincblende, pyrites, and blue and green carbonates of copper from Fogwell and Party's claim. One sample from this locality shows an assay value of 5 oz. 8½ dwt. of gold per ton. Mr. Geological-Surveyor David, who examined this field, states that:—

"Gold occurs here in numbers of thin veins of quartz traversing a felsite breccia, and the latter also is auriferous for several feet on either side of the quartz veins. Diorite occurs about a quarter of a mile S.E. from the Prospectors;

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* Government Geologist's Report—Annual Report, Department of Mines, 1883, p. 152.

and in Hynde's shaft, on the south side of the Grafton Road, adjoining the Prospectors, a dyke of quartzose diorite rock was cut in the West Drive. The dyke strikes N.W. The felsite breccia is variable in character. At a short distance from the ore deposits it is very hard, and consists of angular fragments of opaque whitish-grey felsite from a ¼ inch to 1 foot in diameter, set in a quartzose or felsitic base. In other places, as at Harkness and Party's claim, a quarter of a mile N.N.E. from the Prospectors, the breccia is more dioritic. In the vicinity of the ore deposit, the breccia is very much decomposed, being comparatively soft to a depth of 35 feet from the surface, and is of a prevailing reddish purple colour. . . . the veins are very irregular in strike and dip; and the manner in which the veinstone in most cases passes gradually into the country rock without the intervention of defined walls precludes them from being classed with those fissure veins, in which there is evidence of considerable vertical displacement. They rather resemble shrinkage cracks which have been filled with auriferous metallic sulphides and quartz. The veins at the top of Mount Carrington will prove auriferous to a depth of at least 300 feet, as is proved by natural sections. At this depth the veins will be better defined, but probably more contracted, and the country will become harder. There are two kinds of ore to be treated—(1) the oxides, and (2) the sulphides. The latter are by far the most important, as the former, on the average, do not extend for more than 30 feet below the surface. The oxidized ores in such veins as Bourke's will certainly pay well for working down to the water level.

"As regards the main question as to whether the ores can be worked to advantage below water level, the yield of the sulphides from the veins lying at the base of Mount Carrington is so small (4 dwt., according to assay) that it will not leave sufficient margin to pay for the extraction of the gold from the sulphides of iron, zinc, and copper, unless, as pointed out, the sulphides in the ores be concentrated by machinery. At the higher levels, near the top of Mount Carrington, the veins, as a rule, are wider, and there is a great body of stone which the returns by assay have shown to yield from 4 dwt. up to 2 oz. Experience alone will prove whether a large body of easily won stone with this yield can be worked profitably when it contains ores so difficult of treatment as sulphides of zinc and copper and iron pyrites." *

Auriferous ferruginous quartz was shown from the Confidence Gold-mine, King's Plains. Of the occurrence of the latter the Government Geologist states:—

"The quartz veins, from an inch to 4 feet thick,† are found to intersect in an irregular course, but generally about E. & W., a soft ferruginous siliceous and felspathic dyke, which is from 15 to 45 feet wide, and runs north and south. Gold occurs both in the dyke and in the quartz veins, and the whole dyke mass with the

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* Annual Report, Department of Mines, New South Wales, 1886, p. 159.
† Annual Report, Department of Mines, New South Wales, 1886, p. 134.

veins, is taken out, and put through the battery. I was informed that 7,160 tons crushed had yielded at the rate of about 3 dwt. per ton. The dyke, being soft, is easily worked."

From Copper Hill, near Molong, was shown an exhibit of auriferous quartz. According to the report* of the Government Geologist, Copper Hill is a huge mass of felsite with hornblende porphyry in places, and is traversed by numerous lodes or dykes of porous ferruginous quartz. Auriferous stibnite (sulphide of antimony) from the Eleanora Mine, Hillgrove, sixteen miles east of Armidale, was exhibited in bulk by the Minister for Mines. Of this interesting deposit, the Government Geologist reports:—†

"The country generally consists of rocky hills of no considerable height, but Baker's Creek, which flows through it in a southerly direction, suddenly descends into a large precipitous ravine, called 'The Falls,' which is about 1,600 feet in depth. This abrupt valley, which, like that of the Gara Falls, opens into another of greater magnitude, is a splendid instance of the effects of the denuding agencies which have eroded the slopes of the Great Dividing Range.

"The formations of the country are granite and metamorphosed sedimentary rocks, probably of Devonian age. The antimony reefs crop out in places not only on the hills, but also at various levels on both sides of the deep valley. It traverses altered slates and dips E. 40 N. at an angle of 80°. The reef consists of dark blue siliceous slate crossed by a net-work of quartz veins which give it a brecciated appearance. A granite dyke accompanies the reef, and generally divides it in two. Both the dyke and the reef vary in thickness; thus in the Eleanora Company's claims, the hanging-wall reef is from 6 inches to 18 inches thick, the dyke to 5 feet, and the foot-wall reefs from 1 to 4 feet. Oxide and sulphide of antimony (stibnite) occur in irregular bunches, and also finely disseminated through the reefs, but they are absent in places. Gold is sometimes plainly visible in the quartz."

Auriferous pyritous quartz from Black Range, near Albury, yielding 4 oz. 7 dwt. gold per ton, at a depth of forty feet. Auriferous lode-stuff, consisting of serpentine and calcite, with mispickel and metallic antimony from the New Reform Gold-mining Company, Lucknow, near Orange. The Government Geologist, in a progress report, has the following description of the occurrence of the ore:—

"The reefs occur at the junction of serpentine and hornblende felsite, the latter in places passes into diorite.‡ Along this line of junction is what the miners term the "lode," which, at the surface, is a fissure 6 feet or more in width, extending in a direction S. 50° E., for a distance of 50 chains. It is filled with a red sandy ferruginous clay, containing hard siliceous accretions of irregular shape, locally termed "clinkers." This lode dips to the north-east at an angle of about 65°, though in some places it is nearly vertical.

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* Annual Report, Department of Mines, New South Wales, 1885, p. 130.
† Annual Report, Department of Mines, New South Wales, 1883, p. 153.
‡ Annual Report, Department of Mines, New South Wales, 1881, p. 134.

The hornblendic felsite forms the foot-wall, and the serpentine the hanging wall. In the felsite, at varying distances along the lode, are quartz veins, from a few inches to 6 ft. thick, coming in from the west and abutting against the lodes, which they appear to follow down, and form irregular quartz "pipes" or "shoots," dipping diagonally along the lode towards the east. These veins have only been found to contain payable gold where they occur in the lode and form shoots.

The vein stuff consists of quartz, calcite, felsitic rock, and serpentine, with veins and irregular masses of arsenical iron pyrites disseminated through the mass, which assumes a serpentinous character as it approaches the hanging wall of serpentine, and in this part of the vein occurs the great portion of the rich gold-bearing arsenical pyrites."

Mr. H. W. Newman, manager of the mine, gives the following particulars regarding this mine:—

"It has been worked from the grass to 380 feet slope,* at which level highly satisfactory results daily occur. . . . The vein is 35 feet long, and averages 6 feet wide, and contains three grades of ore, which are shipped monthly to Messrs. Johnson, Maten, & Co., of Swansea. The Reform Co. make four samples of their material: First comes the bulk ore, which consists of the best stone containing pyrites, picked by hand, and sent away in its natural state, which yields from 60 to 80 oz. of gold and many ounces of silver per ton; sometimes the yield is even double what I have quoted, but, as an average, I am about it. Next comes No. 1 crushed ore, the free gold being extracted by the battery process; this ore yields from 30 to 40 oz. per ton, the yield depending entirely upon the separation of the sand from the ore, but it is found judicious, as a rule, to send the ore a little crude, as it pays best. Then there is No. 2 crushed ore; this is obtained from the refuse of No. 1, and returns, according to its cleanliness, from 15 to 20 oz. per ton. And lastly comes the refuse ore, obtained from the various strainings, which is called No. 3; this stuff returns from 2 to 12 oz. per ton."

Auriferous siliceous lode-stuff, with trace of carbonate of copper, and showing free gold was shown from Brown's Creek Mine, near Blayney. The following particulars of this interesting deposit are given in the Government Geologist's Progress Report, 1881:—

"Brown's Creek Gold Mine is situated on the west side of Cowriga Creek, six miles west from Blayney.† The deposit which is being worked is a very remarkable one. It consists of a ferruginous breccia, containing siliceous accretions, or 'clinkers,' and fills a huge fissure, which is in places 150 feet wide, in diorite. It has been formerly worked by a large open excavation about 250 yards in length, but now the auriferous lode-stuff is raised from a shaft sunk close to the crushing plant. The lode-stuff yields at the rate of about 3 dwt. per ton. The gold is very fine, and occurs not only in the softer portion of the lode, but also in the hard flinty accretions, and I believe it has been formed from a thermal solution permeating the lode. Some of the accretions are stained with green silicates and carbonates of copper."

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* Newman.—Extracts and Reports, Lucknow or Wentworth Gold Field, 1888, p. 5.
† Annual Report, Department of Mines, New South Wales, 1881, p. 131.

Mr. T. W. Horton, jun., of Drake, New England, exhibited samples from the interesting auriferous granite deposits at Poverty Point, Timbarra, in the New England District. Where the granite is auriferous it has a talcose structure. Specimens of steatite, with gold freely visible, have been obtained from this locality. The following is extracted from Mr. Horton's description of its occurrence:— *

"The alluvial gold was first discovered by Mr. Dalton (who was afterwards appointed a Gold Commissioner) on M'Leod's Creek. The whole creek proved to be extremely rich, from its rise in the gold-bearing granite formation on the table-land top to its confluence with the Rocky or Timbarra River.

"This table-land top is about the highest portion of the coast range which bounds the Clarence River watershed on this portion of the field. It is the head of M'Leod's Creek, which takes a very erratic course through the mountains (easterly) to its junction with the Rocky River. It is also the head of the Sandy Creek, a main tributary of the Cataract River, running south. It is also the head of innumerable little gullies, all rich in gold, and all radiating from this centre, down the eastern fall into M'Leod's Creek, and down the western side of the range into Sandy Creek.

"The fall into M'Leod's Creek is very precipitous, and each of these little gullies carries its own distinct sample of gold to the junction, and the main creek bed is generally charged with the sample for a few yards below each junction, when the next gully deposits another sample. These samples are all of the same value, but vary in form and fineness. The heads of Sandy Creek and its tributaries were all extremely rich, but the country is flatter, so the gold did not travel far from its source in that direction.

"It was on this table-land top the first gold-bearing granite was found. It here forms a kind of table-land or broad rugged saddle between the heads of the two above-named creeks. The surface soil was first sluiced off to a depth of 4 to 5 feet, on to the hard granite rock. In a year or two afterwards, it was found that the weather had decomposed this rock to a depth of a foot or two; this was again cleaned off to the hard rock and sluiced, and this process has been repeated periodically during the past twenty years.

"From this point, continuing along the range south, we come to Donald Gray's, a remarkable talcose deposit, still on the highest abutment of the edge of the range, overlooking M'Leod's Creek, the Rocky River, Tabulum, and the

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* Letter received from Mr. T. W. Horton, junr.

Richmond ranges, filling three narrow precipitous channels in the granite, and it appears to have been erupted at different periods. Some of the lower levels are impregnated throughout with iron and arsenical pyrites, others with nodules up to 3 inches in diameter. Many other deposits contain no pyrites; they vary from a hard gritty sandstone-like rock to a fine white kaolin clay, which is always very rich in gold. All the pyrites-bearing rock contains gold and silver.

"In some of the beds the pyrites are decomposed, giving the whole rock a reddish tinge; in others, the pyrites nodules are decomposed, without staining the country rock, forming what the miners call 'clinkers,' which are often extremely rich in gold. The deposit yielded the original discoverers 1,000 oz. of gold by hand-crushing and cradling.

"Continuing about 4 miles further along the range, we find the "tin swamp." Here in the swamps and gullies are alluvial deposits of ruby tin, associated with wolfram, manganese, tourmaline, and a little gold; but not payable.

"Six miles further south brings us to Poverty Point and the Great Sluicing Hill Gold-mining Company's claim. This is situated at the extreme end of the range, where it is cut off by the deep channel of the Rocky River. The claim is only 3 miles from the river, but 2,300 feet above the level of the river bed. The samples exhibited came from this locality. The original holders, ordinary sluicers, found gold in the grass roots all over the surface of the hill. Being at such a great elevation, they could only command the water-shed from the few tops of mountains standing at a higher elevation, and only got this under great difficulties. The result was that for many years they had never sufficient water to sluice for more than thirteen weeks in the year, and they regularly realized about £2,500 worth of gold per man per year. Some of the original holders have been working on the ground about thirty years, and are there still.

"The deposit has the appearance of alternate vertical belts of hard and soft granite, terminating abruptly at its southern end against a large vertical porphyritic dyke. The softer portions of the deposit have been sluiced away to an average depth of 40 feet by 40 feet wide, when the walls and bottom rocks become so hard that the action of the water cannot break up the particles of rock finely enough to liberate the gold, which is of an extremely fine nature: so fine that I have washed good prospects of gold from small tufts of moss and fine grass roots growing on the banks and boulders in the water-course, 5 miles below the workings. The gold has been carried down either in suspension in the water or enclosed in fine particles of sand, which had gradually worn away as they travelled down the range. A remarkable feature in the formation is that the whole of the auriferous granite formation, as well as the barren granite on either side, is traversed by three small smoky quartz veins, containing molybdenite and a little bismuth, and are rich in gold not only in the auriferous but in the barren country on either side, while the auriferous rock is much richer in close proximity to the veins than it is throughout the entire mass. A number of immensely large granite boulders are seen about the surface, some embedded, others resting on the surface, others standing up, just balanced, on the most elevated points of the range, giving a splendid illustration of the denudation of the mountain range and of the liberation of the free alluvial gold. In the workings occasionally, vughs are found near the veins, lined with quartz crystals, set in well-formed white crystals of orthoclase.

"Several other deposits of this same granite formation occur in the neighbourhood on a much larger scale, which, although not sufficiently rich to pay for working, have, by the slow process of denudation during past ages, liberated sufficient gold to make the creeks and gullies leading from them exceedingly rich.

"In addition to the large deposits of auriferous rocks above described, greisen and dioritic dykes are occasionally met with, containing gold either free or in combination with pyrites, bismuth, and molybdenite. They have no defined walls or regular strike through the country; but sufficient work has not yet been done upon any of them to determine their structure or value.

"The auriferous granite differs from the ordinary country rock of the district in a few minor points. In the auriferous granite, the particles of quartz composing it have a smoky stain, and occasionally large, well-formed crystals of orthoclase are met with, say one in a cubic foot, while in the ordinary granite the quartz particles are of a white or greyish colour. The felspar in both rocks is in the same form, but varying in colour from white to all shades of red.

"In the country rocks the orthoclase crystals are not met with except in dykes, but they occur abundantly in the granite on the river (say) 2,000 feet below, with large quantities of titanic and magnetic iron. The quartz particles here are white, and carry no gold. Some very nice specimens of oligoclase are also found in the dykes here.

"I need not give you the history of the failure of the company who attempted to 'sluice' the hard granite mountain away, or the result of their late attempt to crush the mountain with a small plant, and a short supply of water; but I can safely say that there are millions of tons of stone that will yield from 2½ to 3 dwt. of free gold per ton, and I see nothing to prevent it becoming a good continuous dividend-paying property for an unlimited period, providing a sufficiently extensive plant was supplied.

"Statistics show that the Timbarra gold escort returns, from 1859 to 1866 inclusive, amounted to 71,058 oz. of gold; and I know that large quantities during this time went down by private hands, and since that date, during the past twenty-eight years the field has been continuously worked by Chinese and Europeans."

The Great Red Rock Gold-mining Company exhibited auriferous lode-stuff from the Fairfield Gold-field. The general characteristics of the reefs in this field have already been quoted from Mr. Geological-Surveyor David's Report (Annual Report, Department of Mines, 1886).

The Mining Registrar of the Fairfield division of the New England mining district has the following notice of the Red Rock Mine)*:—"At Red Rock, about 8 miles N.W. from Fairfield, the gold is found in gossan stone with quartz; it occurs not in veins or reefs, but in great masses. The average yield is estimated at 5 to 15 dwt. per ton. The Red Rock Company obtain their stone from an open cut or quarry in the mountain; the face is 25 to 30 feet wide, and the depth of the cutting is 20 feet. . . . The last crushing yielded 8 to 10 dwt. per ton. . . The stone is said to be practically inexhaustible, and it is estimated that 3 dwt. per ton will pay for working."

Auriferous quartz, with sulphide of antimony, was exhibited from the Razorback Gold and Antimony Mines, eighteen miles from Capertee. Of this reef the Government Geologist reports †:—"At Razorback an auriferous quartz reef, containing iron pyrites and sulphide of antimony, traverses black slate country. It occurs like the Eleanora Mine, near Armidale, with a trap dyke, and varies in thickness up to 3 feet 6 inches, dipping W. 25° S., at an angle of 1 in 6. As it follows the dyke it will probably be permanent in depth."

A trophy of auriferous quartz was shown from the Baker's Creek Gold-mine, Hillgrove, near Armidale. The veinstone is a greyish-blue quartz, slightly brecciated in places by the inclusion of fragments of black slate, and showing a casing of a similar slate; it is very free from pyrites. A little sulphide of antimony is present. The gold is freely visible, penetrating the stone, and very evenly disseminated through its entire thickness. The exhibitors had a number of specimens taken at random from the trophy cut and smoothed, and a magnifying glass attached to the stand, so that observers could see the richness of the stone. A recent crushing ~~of 200~~ tons yielded 3,007 oz. of gold. Since the closing of the Exhibition this exhibit, weighing a little under 15 cwts., yielded within 2 dwts. of 55 oz. of fine gold.

The Golden Gully Gold-mining Company, Ironbarks, exhibited a very interesting suite of specimens, showing gold associated with mispickel (arsenical pyrites) in quartz and calcite. Some of the oxidized specimens show a concretionary nodular character, and have evidently resulted from the decomposition of pyrites. These samples contain a considerable amount of gold.

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* Annual Report, Department of Mines, 1887, p. 99.

† Ibid, 1886, p. 138.

From the Gordon Mines, Yeoval, the Minister for Mines exhibited a considerable quantity of ore, consisting of auriferous yellow sulphide of copper and a little zinc blende in quartz. The Inspector of Mines, W. H. J. Slee, F.G.S., gives the following account of this deposit:—*

"The formation in which this mine is situated is granite, and the lode or deposit occurs in an irregular mass of quartz veins in a circular form, which contain gold, carbonates of copper, copper pyrites, blende, and molybdenite. These veins have been taken out and crushed to a depth of 120 feet from the surface. The whole of the workings represent a pit or quarry, 120 feet in depth by about 70 feet in diameter. Everything, whether rock or quartz, has been crushed. . . . For the present the mine is being worked for gold only (copper being too low in price), the monthly crushings averaging 150 tons, and the yield of gold from 3 to 7 dwt. per ton. There are also about 1,000 tons of concentrated copper ore lying near the crushing machinery. Mr. Veitch, the manager, informed me that assays of the ore gave 9 per cent. of copper, 12 dwt. of gold, and 2 oz. of silver per ton."

Mr. C. A. Chesney exhibited a bulk sample of ore from the Chesney Cobar Gold-mining Company's Mine. It consists of ferruginous quartz and sandy slate, the gold being principally in the latter; the gold in fine grains being intimately mixed with the component particles of the sandy slate, assays of which have given very high returns.

Mr. C. A. Chesney, B.E., Civil Engineer, states:—†

The above property "consists of three blocks of 5 acres each and one of 10 acres, making in all 25 acres held under gold-mining lease, 50 acres held as a water right, and 100 acres of freehold land, making a total of 175 acres. The reefs, which are traceable all through the land under gold-mining lease, have a width of 160 feet on the surface. Four shafts have been sunk, in all of which payable gold, it is said, has been found. The 600 tons of ore at grass are estimated to return, by ordinary crushing, 2 oz. of gold per ton; while, if the chlorination process be used—some of the gold being very fine—an equal quantity may be expected to be saved from the tailings. Several bulk crushings have been made from this property. Two tons from the surface sent to the Sydney Mint yielded 4 oz. 10½ dwt. gold per ton, while the assay of tailings gave 1 oz. 18½ dwt. per ton, making a total of 6 oz. 9 dwt. per ton; the gold being worth £4 2s. 1d. per oz., a very high standard indeed. In fact, all the silver contained in the stone was valued by the Mint authorities at only one penny per ton, thus proving the good quality of the gold. The bullion assay was $\frac{966}{1000}$, silver, $\frac{30}{1000}$. A further lot of 28 tons were forwarded to Victoria. Fourteen of these yielded, by ordinary battery treatment, 1 oz. 17 dwt. of gold per ton, no assays having been made of the tailings. The other 14 tons were submitted to the chlorination process, which produced 2 oz. 3 dwt. 15 gr. of gold per ton. A further lot of 1½ tons taken from a trench on the property, on treatment gave 1 oz. 2 dwt. gold per ton; so that the 31½ tons fair sample, taken from the mine and submitted to treatment, gave an average return of about 2¼ oz. of gold per ton, which at (say) £4 2s. per ounce value, equals a gross return of over £9 per ton, a good enough result when here are by late calculations an estimated quantity of auriferous stone in sight of 100,000 tons . . . .

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* Annual Report, Department of Mines, New South Wales, 1886, p. 107.

† Mineral Resources Cobar District, Chesney, 1888, p. 7.

"The freehold land of the company is so situated that it forms one of the best catches for storm water in the Cobar district, while for a machinery or residence site it is unsurpassed. Tenders have been called for the erection of a large gold-saving plant; and, at present, there is machinery on the ground which is capable, when erected, of putting through about 120 tons of stone per week. A large reservoir, to contain about 40,000 cubic yards of water, is being constructed."

I understand from Mr. Geological-Surveyor Anderson—who has cursorily examined this locality—that the reef is on the same line of fracture as the Great Cobar Copper-mine (though in all probability a fault has occurred between the two places, having a considerable lateral displacement), a fact which receives confirmation from the occurrence of gold in the latter mine; an assay made by the Department of Mines of the refined copper produced at Cobar revealed the presence of gold at the rate of 2 oz. 12 dwt. 4 gr. per ton.

The Mount Billagoe Prospecting Syndicate exhibited a bulk sample of ferruginous quartz and slaty lode-stuff from their mine. The following is from the Warden's report:—

"At Mount Billagoe, 30 miles north-west of Cobar, a shaft has been sunk 100 feet, and a drive put in 40 feet. A reef has been cut from which some samples of gold-bearing quartz were taken. Some of the stone tested, it is said, gave over 5 oz. of gold, and 90 oz. of silver per ton." *

Mr. C. A. Chesney, B.E., in his "Mineral Resources of the Cobar District, New South Wales," states:—

"From 1½ tons of stone taken from the 90 feet level by the present syndicate, and treated at the Ballarat School of Mines, the average return per ton by ordinary treatment was:—

	oz.	dwt.	gr.
Gold	4	10	10
Assays of tailings	1	8	19
Total	5	19	5
	oz.	dwt.	gr.
Silver	34	8	2
Assay of tailings	41	13	21
Total	76	1	23"

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* Annual Report, Department of Mines, New South Wales, 1887, p. 108.

The occurrence of gold in payable quantity in the Barrier Ranges is evidenced by the exhibit from the Princess Midas Gold-mine, Purnamoota; assays of which are reported to have yielded very satisfactory results; the auriferous vein stuff consists of ferruginous quartz and copper ore, in one specimen coarse gold is plainly visible. From another mine in this district (M'Grath's Red Jacket Mine) the Minister for Mines exhibited auriferous quartz veinstone stained with green carbonate of copper, which yielded on assay 3 dwt. of gold per ton.

From the frequent occurrence of quartz reefs throughout this district, in many instances forming conspicuous objects in the landscape, owing to the removal by denudation of the softer enclosing rocks; it is extremely probable that prospecting, which has hitherto been principally, if not entirely, confined to searching for silver lodes, will yet reveal the presence of many reefs which will prove payably auriferous, whilst under the extensive alluvial flats formed from the degradation of the higher levels traversed by these reefs, payable deposits of alluvial gold may yet be found.

Gold in serpentine (marmolite), and associated with asbestos, was discovered by the Gundagai and Melbourne Asbestos Company, at their mine on Jones' Creek, about four miles from Gundagai. A crushing of twenty tons yielded at the rate of 2 oz. of gold per ton. The Government Geologist, who recorded the discovery in his Progress Report* regards it as an important one in connection with the various modes of occurrence of gold, and expresses the opinion that it is not improbable that nuggets of gold occur in such rocks in the same manner as masses of native copper sometimes do. In this case, however, the gold was as fine as gold leaf, and occurred between the layers of the marmolite.

Mr. Geological-Surveyor Pittman, who also examined this deposit, in his report † states that "the gold occurs in a similar lode (to the asbestos) consisting of serpentine identical with the adjoining country, but filling the space between well-defined walls, which in this instance, are from six to twelve inches apart. The gold ran out at a depth of ninety feet, and was last seen in the hanging wall, but was not followed up." Specimens of this interesting occurrence of gold were shown in the Minister for Mines' collection, and in that of Professor Liversidge.

Mr. J. H. Blatchford exhibited auriferous quartz, with galena, zinc blende, copper, and iron pyrites from Snobb's Reef, Braidwood.

From the Homeward Bound Gold-mine, Yalwal, were shown some very rich specimens of ferruginous quartz, the gold being very freely-visible. Of this mine Mr. Pittman reports ‡—"The Homeward Bound Gold-mining Company are at present working an open quarry at the surface. The gold is visible in small veins of gossan, running through the stone irregularly, and probably derived from the decomposition of pyrites. The last crushing from this spot yielded 1 oz. per ton nearly. The mine is also pierced by a long tunnel, nearly 300 feet, which was put in from the side of the mountain to strike the bottom of their shaft. Several slides came in this tunnel, each slide carrying a large body of stone containing from 4 to 10 dwt. of gold per ton. Several crushings were also made of stone taken from the shaft, where these slides were encountered, and yielded from 9 dwt. to 1 oz. of gold per ton, the richest yield being from near the surface. Another patch of 100 tons was extracted by quarrying at the surface near the shaft, and yielded an average of 3 oz. 13 dwt. of gold per ton."

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* Annual Report, Department of Mines, 1879, p. 217.
† Annual Report, Department of Mines, 1881, p. 140.
‡ Annual Report, Department of Mines, 1883, p. 159.

The following additional particulars have been furnished by Mr. R. T. Thorburn, Managing Director:—

"The mine named above is situated on the right bank of Dangera Creek, a tributary of Yalwal Creek, which joins the Shoalhaven River, about thirty miles—as the crow flies—west of the mouth of the Shoalhaven.

"Yalwal Gold-field contains an area of ninety-seven square miles. Gold was first discovered there in the alluvial in 1852, and it was proclaimed a gold-field in 1876.

"The first Homeward Bound ground lease of five acres was issued by the Crown in 1877, but the ground was but spasmodically worked until it came into the possession of the present lessees, Messrs. R. T. Thorburn, John Faulks, jun., Reuben Mison, and Ephraim Mison. The lessees at that time being men actively engaged in other spheres of emolument, only a limited number of men were employed in the mine. There was, from 1880 to 1886, but one "public" reducing plant at Yalwal, and this battery was generally employed on trial crushings for prospecting parties. Hence the Homeward lessees, having to pay a high tariff for crushing, and being but feeling their way in the Homeward Bound treasures, had but the very best stone crushed in the battery, until it became their own property in 1886. Since then the stone has been almost indiscriminately put through the battery, giving the result declared further on.

"The lease occupies part of the western side of a ridge of quartzose rock, running nearly north and south, of an altitude at its apex of 300 feet above tidal water, and 250 feet above the adjoining stream, Dangera Creek. The ridge starts from the south table-land, and stretches north 10° west for about two miles, being but two or three chains wide at its crown, at the Homeward Bound, and narrowing off to a sharply-defined ridge, northerly, till it terminates where Dangera Creek is joined by Sawpit Gully Creek, twenty chains or so further north.

"The width and depth of the lode which is being worked—quartzite, with numerous thread-like veins of pure quartz, carrying gold,—is not yet defined, though in the claim under notice it has been taken out from a depth of sixty feet, and a width of over sixty feet.

"The records kept since 1882, show that about five men have been kept at work in the mine, exclusive of those employed in connection with the battery. The mode of conveying the stone from the mine to the battery is by horse traction; but the proprietory contemplate a more effective and economical mode of carriage by rail and gravitation. The battery is one of ten stamps, but with the immense quantity of payable stone now in view, a much larger battery could be kept in full work, with about the same complement of hands continuously working in the mine. The average yield of the stone since the mine was opened exceeds one ounce of gold per ton. The total value of the gold and silver produced to February, 1889, is £26,251 4s. 7d."

Mr. J. E. Kelly, M.P., exhibited samples of the auriferous lode-stuff from the Delaney's Dyke Gold-mine, near Molong, in which gold could be seen. The Government Geologist states that the lode consists of brown iron ore on the footwall side, passing towards the hanging wall side into siliceous "clinker," or chalcedonic quartz and contorted shale. It contains also garnet rock, and is stained throughout with copper carbonates. It strikes north and south and dips east at 40°, and is twenty-six feet wide on the surface.

Since the Government Geologist made the above notes, Mr. Kelly informs me that prospecting has proved the auriferous portion of the lode to increase from seven feet in thickness at thirteen feet from surface to twelve feet at the 100-ft. level. It has been driven on from this level about 100 feet north and south. At both ends the lode shows gold freely. No bulk crushing has yet been done from this level owing to want of water, but assays of picked samples have yieled up to 80 oz. of gold per ton. Sixty tons, taken from surface to sixty feet, yielded 1 oz. of gold per ton. The gold is very light-coloured, and consists of an alloy of two parts gold and one part silver. It is worthy of note that gold has been found in the garnet rock.

The Mount Gray Gold-mining Syndicate exhibited auriferous lode-stuff from Mount Gray. The following particulars were furnished by the Secretary to the Syndicate:—

"The property is situated on Grove Creek, between Trunkey and Tuena, in the vicinity of the Abercrombie Caves, and about twenty-seven miles from Newbridge railway station, on the Western line. The country consists of crystalline limestone interstratified with slate, both of which are striking north and south, and standing nearly vertical. To the west of the property is a massive deposit of limestone, in which occur the Abercrombie Caves. A parallel belt runs through the syndicate's ground, and in it the lode occurs in a very irregular manner.

The lode-stuff consists of a hard ferruginous quartz, with veins of white quartz, and others of a porous nature, intersecting it.

Mr. H. S. Cox, F.G.S. (Messrs. Cox and Seaver), who examined the property, states that at one place the lode traced by outcrops, is as much as 230 feet wide, and he concludes his report by stating that the work for a time will be of the nature of a quarry, fully 200,000 tons of ore being in sight, which he expected to yield about an ounce of gold to the ton. Nine different samples chosen by Mr. Cox yielded from 13 dwt. 1 gr. to 6 oz. 10 dwt. 7 gr. per ton.

IV.—Silver.

The display of silver ores was very large and varied, and the localities represented reveal how wide-spread is their occurrence, from Monaro in the south to Rivertree and Fairfield in the north, and from Sunny Corner in the east to The Barrier Ranges in the west.

The value of the silver and silver lead produced in the Colony to the end of 1887 was £1,806,349. The following extract from the Government Geologist's Report on the Silver-bearing Lodes of the Barrier Ranges, August, 1884, will be of interest:—

"I have examined eighty-one lodes, and there are a few others, the Day Dawn, Ophir, Black Prince, &c., that I did not see; but those above described include all the principal ones, and from them it will be seen:—

"1. That the geological formations which contain the argentiferous lodes of the Barrier Range Silver-field are mica-schists, clay-slates, and sandstones, traversed by numerous quartz reefs, and intrusive masses and dykes of coarsely crystalline granite (pegmatite), and diorite. Nearly all the lodes occurr in the mica schists, and they have been found over a tract of country 70 miles long and 30 miles wide, which has been only partly prospected, so that many more lodes will probably be discovered. But the metalliferous formations are known to occupy a much larger area, and extend to Kooringbury on the north, and on the east as far as the Eight-mile Tank on the road to Silverton, about 38 miles from Wilcannia. . . . . .

"2. That the lodes, with the exception of those of the Broken Hill and Pinnacles, which are chiefly composed of ferruginous quartzite, all consist either of brown iron ore (gossan) containing argentiferous carbonate of lead and galena in bunches, and sometimes chloride and chlorobromide of silver, and carbonate of copper; or rarely of argentiferous carbonate of lead and galena alone; quartz is sometimes, though not always, present, and, in one instance, baryta occurs. It is evident that the oxides, carbonates, and chlorides have resulted from the decomposition of the sulphides, and perhaps arsenides of iron, lead, silver, and copper, &c., which will be met with in their original condition below the water-level. Sulphides of lead (galena), and in two instances, iron pyrites are even found above the water-level.

"3. That the lodes, without exception, are very inconstant in thickness, both in longitudinal and vertical extent, and many of them thin out entirely within a few yards. A surface plan of the numerous lodes would resemble the shrinkage cracks upon the surface of a dried piece of cross-grained wood; in fact, as before mentioned, the lode fissures were shrinkage cracks formed by the contraction of the rock mass after the intrusion of the igneous rocks."

"Some of the lodes appear to have been formed along an original joint in the strata, which is indicated by a well-defined wall in the lodes; and these will, I believe, continue to great depths, though varying in thickness in places."

Samples from various mines in this field were shown in the collection of hand specimens exhibited by the Minister for Mines.

The Broken Hill Proprietary Company, in the show-cases at the base of their trophy, exhibited a number of specimens illustrating the nature of the argentiferous ores occurring in this truly wonderful mine, viz.: massive carbonate of lead with chloride of silver; kaolin, with chloride of silver; manganese oxide (stalactitic, and mammillated), with chloride of silver; the former in some instances showing beautiful crystals of calamine (carbonate of zinc) and chloride of silver; beautiful coral-like masses of the latter were also shown. Native copper, with a coating of malachite, as a product of oxidation, and handsome dendritic forms of native copper were also displayed. Galena (sulphide of lead) is shown from the lowest level. In addition to the carbonate and sulphide of lead, the sulphate (anglesite) and phosphate (pyromorphite) were shown.

The following is the produce of the Broken Hill Proprietary Silver-mine, to January 24th, 1889:—

Ore treated.				Bullion obtained.				Fine Silver.	Lead.				Average of fine Silver per ton.
Tons	cwt.	qr.	lb.	tons	cwt.	qr.	lb.	ounces.	tons	cwt.	qr.	lb.	ounces.
170,391	6	3	11	31,259	19	2	10	7,782,549	31,027	11	1	10	45·67

From the reports of the general manager, Mr. Patton, and the metallurgist, Mr. Schlapp, it will be seen that during the six months ending November 30th, 1888, 55,846 gross tons of ore were extracted from the mine, which yielded an average of seventeen per cent. of lead, and 42·9 ounces of silver per ton, at a cost of 18s. 9·65d. per ton for mining and placing in the mine-dumps, and £1 15s. 6d. per ton for smelting.

The cost of the latter being made up as follows :—

	s.	d.
Labour	9	8
Superintendence—Assay Office, &c.	0	6
Cost of coke	18	4
Cost of firewood	1	0
Limestone	4	10
Repairs, &c.	1	2
	£1 15	6

Mr. Schlapp reported that the limited water supply available during July and August, necessitating constant reusing, proved very destructive to the jackets of the furnaces owing to the water becoming highly charged with mineral matter.

It is worthy of note that the expenditure for coke during the above period was £71,002 17s. 11d. exclusive of freight, which amounted to £27,867 9s. 1d. The Australian supply of coke is recorded as being not only limited, but inferior in quality to the imported article—a stigma upon our coal industry which can surely be removed by increased attention to the manufacture of coke for smelting purposes.

The cost of timber for mine purposes was £22,050 8s. 10d. for the six months referred to. Tenders have been accepted for a monthly supply of 500,000 ft. from outside the Colony.

A concentrating or ore-dressing plant, with a capacity of treating 250 to 300 tons daily, was close upon completion at the time of report.

The total number of men and boys employed was 1,666, of this number 1,057 were engaged in the mine.

* The Government Geologist, thus alludes to this mine :—

"With the Inspector of Mines, Mr. Slee, I visited the Broken Hill Mine, and was shown through the underground working by Mr. Patton, the newly appointed general manager, and Captain Piper, mining manager. I was surprised at the large amount of work that has been done in proving this splendid lode to a depth of 316 feet, the water-level being about 240 feet. It is a true fissure lode, varying from 10 to 160 feet wide, and consists chiefly of porous iron and manganese oxide in places, more or less siliceous, containing carbonate of lead and chloride of silver, with occasionally carbonates of copper and zinc. These ores have resulted from the decomposition of sulphides and arsenides, which will be found in unaltered original condition below the water-level. As one looks at the sides and headings of the drives, the gossan lode-stuff, with its cavities and joints sparkling with crystals of cerussite and chloride of silver, presents a most interesting and fascinating sight. In one large natural cavity in the lode the sides were lined with black stalactites of iron ore, spangled over with white translucent crystals of carbonate of lead and carbonate of zinc, together with pale green crystals of chloride of silver, treasures for a mineralogical museum. Sometimes the gossan is intermixed with kaolin and garnets, and in places occur angular fragments, embedded in various positions, and of all sizes, of mica slate, granite, and quartz, which had fallen from the sides of the fissure. The walls of the lode are well defined, especially the hanging wall, which, in two places I measured, dips to the N.W. at 65°, but the dip varies in other places, and has changed to the E. below the 217-ft. level in M'Culloch's shaft. I noticed that one projection on the hanging wall had been rounded and striated by a faulting or downward sliding movement northerly at an angle of 47°. This is an important feature, showing that though the lode must necessarily vary in width, it will continue, as far as the displacement or sliding movement of the hanging wall has taken place, probably to a great depth. The lode continues northerly with much the same character, narrowing and widening in places through block 14, 15, 16, and Broken Hill Junction, beyond which it seems to continue in irregular smaller lodes of a more siliceous nature, containing argentiferous galena and carbonate of lead and copper, with a little chloride of silver. To the south also it passes into quartzite lodes, containing silver, lead, and copper ores sparingly distributed through the lode-stuff. Similar unpromising quartzite lodes crop out again about 3 miles further south in the Rise and Shine Company's ground, together with several ironstone lodes, one 8 feet thick and others 1 foot and 1 foot 6 inches thick respectively, containing carbonate of lead, which, I was informed, gave an assay up to 80 oz. of silver per ton. These gossan and lead lodes should be prospected to greater depths."

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* Annual Report, Department of Mines, New South Wales, 1887, p. 143.

The Broken Hill Junction Mine exhibited crystallized carbonate of lead, with carbonate of zinc and chloride of silver; also several massive blocks of carbonate of lead with carbonate of copper.

The Barrier Range Mine Managers' Association exhibited a very interesting series of ores from the following mines on this lode:—Broken Hill Proprietary, Junction, Central, South, and North.

The Broken Hill Block 14 Company exhibited handsome specimens of crystallized carbonate of lead, and pyromorphite. From the lowest levels massive galena was shown, also carbonate and sulphide of lead intimately associated, showing the transition by alteration of the sulphides into carbonates.

Smelting has lately been commenced at this mine, first with one and lately with two smelters, the output being 826 tons 0 cwt. 3 qrs. 4 lbs. of bullion, containing 822 tons 13 cwts. 0 qrs. 19 lbs. of lead, and 110,490 ounces of silver. Splendid concentrating machinery has been erected, and tried with most satisfactory results.

The ores from the Proprietary and Junction mines corresponded with those already described, with the addition of native silver in siliceous iron and lead ores from the latter mine.

The ores from the Central were siliceous ironstone, carbonate of zinc, and chloride of silver.

From the "South" the ores were siliceous ironstone with kaolin and chloride of silver, carbonate, sulphate and sulphide of lead, with iron and manganese oxides, and carbonates of copper.

From the "North," carbonate, phosphate, and sulphide of lead, with native silver and copper.

The Mine Manager's Association exhibited copper ore with chloride of silver from the War Dance Silver-mining Company, near Purnamoota. Referring to this mine the Government Geologist states*:—"Three small lodes have been opened in the slate country. In one which dips S.S.E. 45°, with a well-defined hanging-wall, carbonates of copper, richly streaked with chloride of silver, occur with the gossan. About 150 feet from this is another parallel vein, 4 feet 6 inches thick of gossan, carbonate of copper, and chloride of silver. Three chains further S.E., in a shaft 20 feet deep, another gossan lode, showing chloride of silver has been opened. These lodes, though small, yield rich ore, and appear to be of a permanent character."

From the Victoria Silver-mining Company, galena. From the Great Britain and Great Britain East Silver-mining Companies, galena and siliceous ironstone with galena. Galena from the Original Victory Silver-mining Company. Copper ore from the Red Flag Mine. Siliceous galena and carbonate of copper from the Silver King Silver-mining Company's mine. From the Rockwell Amalgamated Silver-mining Company (Limited) specimens of ferruginous quartzite with galena and garnets, ironstone with blue carbonate of copper, and samples of the country rock. Ores from the Sydney Rockwell Silver-mining Company. From the Kaiser Silver-mining Company sulphide and carbonate of lead, and portions of the lode showing kaolin and galena. Ironstone and manganese, with carbonate of lead, from 100-ft. level, Rising Sun Silver-mining Company. From 130-ft. level, White Lead Silver-mining Company, carbonate of lead assaying 107 oz. 16 dwt. of silver and 50 per cent. of lead, and carbonate of lead showing chloride of silver, galena assaying

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* Annual Report, Department of Mines, New South Wales, 1887, p. 143.

51 oz. 9 dwt. silver per ton and 40 per cent. of metallic lead. From the Red Hill Gold and Silver-mining Company, from 70-ft. level, galena with pyrites, assaying 150 oz. silver and 7 dwt. gold per ton; also blende and pyrites. Galena and country rock (mica-schist) from the Shamrock Silver-mining Company. From the Maiden Silver-mining Company, schist with garnets from 35-ft., assaying 15 to 150 oz. per ton, and schist with galena. From the Great Barrier Copper and Silver syndicate, blue and green carbonates of copper; average assay, 29 oz. 8 dwt. silver per ton, and copper 29 per cent. Carbonate of copper from Copper Blow Copper-mining Company. Specimens showing uniform dissemination of galena through the lode from the Kinchega Rockwell Silver-mining Company. From the Alberta Silver-mining Company, Thackaringa, were shown by the Association some massive blocks of coarse and fine-grained galena of an assay value of 60·42 oz. silver per ton and 74·25 per cent. lead.

A similar ore was shown from the Pioneer Silver and Lead Mine, Thackaringa, assaying 49 oz. silver per ton and 82·25 per cent. of lead. The seconds for concentration (from this mine) yield 15·5 oz. silver per ton and 30 per cent. lead.

A siliceous, garnetiferous galena ore was shown from the Parnell Silver-mining Company.

The above complete the interesting suite of ores exhibited by the Association.

The Barrier Range Silver-field was also represented by a massive exhibit of blocks of galena (both coarse and fine grained) from the Gipsy Girl Silver-mining Company, Thackaringa, having an assay value of 43 oz. of silver, and 64 per cent. of lead.

The Government Geologist states*:—

"At Thackaringa, within a radius of 4 miles, upwards of thirty silver-bearing lodes have been discovered; of these I examined twenty-two. As they are nearly all of the same nature, viz., lenticular lodes of gossan, with carbonate of lead and galena, I need only describe a few, showing their characteristic features.

"On the Gipsy Girl Company's property, the No. 1 lode, which has been opened to a depth of 20 feet, following the underlay from the surface, and also in a shaft 40-foot deep, varies from 6 inches to 3 feet thick, and consists of carbonate of lead and galena, accompanied by quartz and ironstone stained with carbonate of copper. It dips N. 20° W. at 30°, traversing mica-schist, and is in one place divided by a horse of granite. It appears on the surface for about 7 chains, then a small ferruginous quartz and galena vein comes in, dipping E. 10°, S. at 35." Mr. Norman Taylor, in a special report made for this company, states that the ores from this mine average generally about 70 per cent. lead, and 35 ounces of silver per ton; and expresses a high opinion of the future permanence and productiveness of the vein worked.

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* Report on the silver-bearing lodes of the Barrier Ranges, 1884, p. 9.

The Mascotte Silver-lead Mining Company exhibited splendid samples of chloride of silver, locally known as slugs, specimens of which having been cut revealed a face of metallic silver from the rubbing.

Mr. Joseph Morgan exhibited a quantity of massive coarse-grained galena from the Christmas Mine, Purnamoota.

The New Year Silver-mining Company, Lakes Camp, Barrier Range, exhibited a quantity of plumbiferous lode-stuff, richly impregnated with native silver, and chloride of silver, assaying at the rate of 10,500 oz. of silver per ton. A quantity of similar lode-stuff, with less native silver, yielding 1,260 oz. per ton; and fine-grained galena, yielding 72 oz. of silver per ton, and 80 per cent. of metallic lead.

The Pinnacles Tribute Silver-mining Company exhibited siliceous garnetiferous galena from their mine. Of this mine the Government Geologist says*:—

"The Pinnacles are situated about 15 miles S.E. from Silverton. There are two main lodes, one of them, the Minnie Moore, has a general strike to the north-west for about 10 chains. In one shaft, 7 feet deep, the lode is seen to be from 3 feet 6 inches to 4 feet wide, dipping W. 30° S. at 70° in talcose mica-schist, and consisting of ferruginous crystalline quartzite, with galena interspersed here and there through it, and patches of yellow gossan. An average sample taken from the whole width of the lode gave on assay at the rate of 78 oz. 8 dwt. of silver per ton, and 32·40 per cent. of lead; and of the yellow gossan, 22 oz. 1 dwt. of silver per ton, and 3 per cent. of lead, with traces (under 2 dwt.) of gold. The hanging wall is ferruginous chlorite rock. The lode winds about, and in one place suddenly widens to 30 feet; in two places it divides for a few yards, and then unites again, in others it sends out branches, which thin out entirely. Within 4 chains of it, on the north-east side, two other smaller lodes crop out. About 5 chains to the south west is a mass of ironstone 12 feet wide in the middle, then thinning out within a length of 50 feet. This forms the end of the Charlotte Greenaway lode, which runs to the south-west for about 10 chains, with a widening course like the lode just mentioned, and varying in width from 2 to 36 feet. It also consists of ferruginous quartzite, containing patches of galena. From the south-east side there is a branch lode, 15 feet long and 4 feet wide, with galena; and 50 feet off on the north-west side, is a separate and nearly parallel lode about 6 chains long, and varying in thickness up to 20 feet, with galena irregularly distributed through it. A sample of the ore which I took from near the surface, and consisting chiefly of galena, yielded on assay at the rate of 53 oz. 1½ dwt. of silver per ton, and 41·12 per cent of lead, with traces of gold. . . . . It will be seen that these lodes are of large size, and I consider that they will be permanent. . . . . The chief silver-bearing ore is the galena, which occurs in patches and grains here and there, and much of it can only be separated from the hard lode-stuff by crushing and concentration. With careful working I think that considerable quantities of payable ore could be raised."

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* Report on the Silver-bearing Lodes of the Barrier Ranges, 1884, p. 8.

The Terrible Dick Silver-mining Company exhibited massive fine-grained galena with carbonate of lead.

The Umberumberka Silver-mining Company, near Silverton, exhibited a quantity of rich lode-stuff, consisting of fine-grained laminated galena, carbonate of lead, and carbonate of iron. Many of the specimens show native silver very freely.

The Government Geologist reports*:—

"The deepest shaft in the district is on the Umberumberka Silver Mining Co.'s lode, about 2 miles west of Silverton. Its depth is 181 feet, and at this level a drive has been put in along the course of the lode for 120 feet from the main shaft in one direction, and for 60 feet in the other. The lode occurs in mica-schists, and dips S. 25° E. at an angle of 75°. It varies in width from 4 to 10 feet, and consists of crumpled mica-schist, traversed by veins and lenticular bunches of brown iron ore or gossan, carbonate of lead, and galena. The hanging-wall is well defined, and coated with a black glossy clay; curved slickensides joints coated in a similar manner run through the lodes in places. The ore, which is said to yield from 70 oz. to 120 oz. of silver to the ton, is chiefly finely crystallized galena distributed in irregular masses in the lode. At the 131-ft. level one of the patches of ore was 12 feet long and 4 feet wide, and in this was a solid mass of galena 2 feet thick; near it iron pyrites is appearing, just as might be expected, for the manager, Mr. Evans, informed me that he had struck water in a bore put down only 2 feet below the floor of the drive."

"The Umberumberka is still the deepest mine in the field, the lode described in my former report having now been worked to a depth of 400 feet, or 267 feet below the water-level. From the 300–360-ft. levels the galena encloses small masses of antimonial silver ore. . . . . A short distance from the lode, on the north side, another lode has been exposed in the railway cutting, where it is 10 feet thick, and dipping S.S.E., almost parallel with the former lode. It consists of iron ore, has a good hanging wall, and every appearance of being a valuable and permanent lode."†

From the Silver King Silver-mining Co., lode-stuff was shown carrying galena and native silver, and assaying 114 oz. of silver per ton.

From the Uno Mine was exhibited a large block of ore largely composed of chloride of silver.

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* Report on the Silver-bearing Lodes of the Barrier Ranges, 1884, p. 1.
† Annual Report, Department of Mines, New South Wales, 1887, p. 143.

Included in the general collection of silver ores exhibited by the Minister for Mines were samples of ores from the following mines in the Mitchell district: Sunny Corner, Tonkin's lease, Nevada, Great Western, Queen, and Monte Christo Silver-mines.

From the Sunny Corner Silver-mine, Mitchell, was an interesting exhibit of seventy-eight bars of metallic silver, weighing 11,214·5 oz., and containing 10,997·01 oz. of fine silver, and 129·8 oz. of fine gold. This exhibit was shown in an upright glass case surmounting a stand with blocks of the ores from which the silver was won, chiefly gossan and sulphide ore.

The Government Geologist gives the following particulars regarding the occurrence of these lodes*:—

" The primary or oldest formation of the district consists of sedimentary altered sandstone and shales. These have been upheaved and intruded by igneous rocks composed of quartzitic elvan and quartz porphyry, which have burst through the sedimentary strata in various directions, but principally north and south, as masses 20 chains, or as narrow dykes only 4 feet thick, consequently the line of junction between the formations is most uneven and irregular. After the eruption of the igneous rocks, fractures or displacements in the rocks took place on at least two different occasions, resulting in the opening of irregular fissures from a few inches to 40 feet wide, in which were deposited the gold and silver-bearing sulphides of iron, copper, lead, zinc, and arsenic, and quartz, constituting the lode-stuff now worked.

" Evidence of these displacements or movements in the rocks may be well seen in the Sunny Corner Mine. A dyke of the elvanite has been split in two, and the fissure filled with clay, showing that the fracture took place after the intrusive rock had solidified; then again the sedimentary formation has in places been displaced from its contact with the igneous rock, appearing to have slipped or moved bodily over the igneous rock, causing, where the original line of junction was curving or uneven, the projecting surfaces of the one formation to abut upon a projecting portion of the other, the intervening concave surfaces forming the irregular cavities now filled with lode-stuff, and, of course, where the line of junction was even or straight, the upper formation has moved upon the other without producing any cavity; consequently, where this occurs, the so-called lodes pinch out, though a well-defined fissure joint continues containing a thin seam of clay fluccan.

" In the Great Western Mine the two different sites of fissures are very clearly seen. We here see that along the line of fracture the surface of the rock has been grooved or striated by the friction or movement of one rock upon the other, and the fissure filled with fragments of the crushed rock. In this fissure-deposit argentiferous sulphides of lead, copper, iron, and zinc have been formed in patches The fissure then opened again and became filled with clay, which, in one place is 20 feet thick, and somewhat resembles a decomposed felspathic basalt rock. Then shrinkage cracks formed in the clay-lode, and were filled with carbonate of lead, probably derived from the decomposition of the galena in the breccia lode.

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* Annual Report, Department of Mines, 1886, p. 139.

" On account of the irregular manner in which the intrusive rock has been intruded, it is, of course, impossible to indicate where the line of junction between the formations is uneven; and, therefore, the whereabouts of any cavities filled with lode-stuff can only be ascertained by actual prospecting along the line of fracture. But we have a general guide in that the sliding movement of the upper formation has taken place towards the north-west; for the ore deposits already discovered occur chiefly upon the north-western slopes of the intrusive formation. This is an important feature, for it affords us assurance that in a north-westerly direction, below the deposits already opened; other similar irregular lodes are likely to be found.

" From the nature of the formation of the lodes, it will be apparent that there is no probability of the occurrence of one main lode in the district; but only of such as those which are at present known, and which are so variable in extent and thickness, notwithstanding that they are true fissure lodes. . . . It will thus be seen that the primary formation of this district consists of Siluro-Devonian sandstones and shales, which have been upheaved and penetrated by elvanite and quartz porphyry; that, subsequently, movements of the rock took place, resulting in the production of the fissures in which the metalliferous ores were deposited, chiefly about the line of junction of the sedimentary and igneous rocks: that these movements having affected the rocks to a considerable extent, the fissures will continue to great depths, though, owing to their irregular form, the ore deposits in them will vary much in thickness; that as these lodes are explored in depth, similar large patchy deposits to those already discovered are likely to be found; that the gossan or oxidized portions of the lodes occurring within about 100 feet from the surface, must soon be exhausted; that the less easily worked unoxidized or sulphide ores will be the permanent class of ores to mine; and that, as these usually are less rich in silver that the gossan ores, weight of ore considered, special appliances for concentrating the sulphides must be employed, especially as the ores are not rich in silver, and will necessitate the most economic methods of treatment, not only for the extraction of the silver, but also of the lead and copper, which are sometimes present to a large extent in the ore. . . I consider that silver-mining on this field will be a permanent and important industry; but its development, which must necessarily be gradual, must to a large extent depend upon (1) the concentration of the sulphide ores, for they are generally of low grade; (2) more economical methods of smelting the sulphides, which will be the permanent class of ore to operate upon; judicious exploration of the lodes;

for, as the ore deposits are very irregular in thickness, having originated, as I have already described, in fissure cavities of varying extent, it will be necessary that the prospecting of the lode should be kept well in advance. The gossan or oxidized portions of the lodes, occurring within 100 feet from the surface, must soon be exhausted, but the depth to which the undecomposed sulphide ores may be found is practically unlimited."

Included in the general collection mentioned above were specimens from the Boorook Silver-field; this locality, as in the case of Sunny Corner, was formerly worked for gold, though the presence of silver was known it was not until about 1878 that attempts were made to win the silver; chloride, bromide, iodide, and sulphide of silver occur in the lodes, the gangue being quartz, and soft red and blue claystone with pyrites, blende, and galena. A specimen of the quartz and pyrites of an assay value of 275 oz. of silver and 2½ oz. of gold per ton, was shown from Addison's lode; the claystone from the Golden Age, assaying 181½ oz. of silver, and 1⅛ oz. of gold per ton. The late Mr. Lamont Young, Geological Surveyor, who visited this locality shortly after mining operations were commenced, stated*:—

"The lodes are situated in belts of felspar-porphyry, alternated with beds of altered and fossiliferous shales, the fossils . . . . are indicative of the Upper Devonian formation . . . . The general strike of the reefs is a little to the east of north and west of south, with a slight dip to the west. . . . The silver-bearing minerals appear to be much disseminated through the matrix of the reefs. Argentite (sulphuret of silver) seems to be the chief source of the silver; there are also present chloride of silver and red silver ore. The associated minerals are iron pyrites in considerable quantity, free gold, copper pyrites, oxide of iron, galena, quartz, and chlorite; the latter mineral in some cases, as in the Golden Crown, forms the walls of the reef."

Mr. B. Davey, M.E., has the following remarks on the lodes which are represented in the collection, viz., Golden Crown, Addison's, and Silver King†:—

"The Golden Age Mine (lease No. 31) is a block of 2 acres, and distant about 2 miles from the granite range. The enclosing rock partakes of the character of a light-coloured talcose clay-slate (killas), which is peculiar to this mine. The lode has a bearing 22° east of north, with a dip or underlie west, and averages about 12 inches wide to the depth of 80 feet, and is composed of quartz, chlorite, clay, and a quantity of oxide of iron. The most abundant ore from surface to 80 feet was chloride of silver, with a little iodide and argentiferous pyrites. All the lode to this depth has been stoped out, and the chloride ore is now exhausted. The yield of silver from this ground has been over 52,000 oz., and 250 oz. of gold . . . . The former shaft (No. 1, 130 feet deep), cuts the blue or sulphide ore at 80 feet, and the lode in the last 50 feet of sinking will average from 18 to 20 inches wide, with a vein on each wall 2 inches thick of rich argentiferous pyrites, which will assay from 70 to 150 oz. of silver per ton. The centre of the lode is composed of a soft blue clay, rather poor in silver. Water was struck in this shaft at 125 feet. No. 2 shaft cuts the blue ore at 82 feet, and the last 60 feet of sinking has gone down on a magnificent lode which will average 30 inches wide and rich in silver. The silver occurs in argentiferous pyrites and blende, some of which assayed as high as 800 oz. of silver and 5 oz. of gold per ton . . . .

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* Annual Report, Department of Mines, New South Wales, 1878, p. 35.

† Annual Report, Department of Mines, New South Wales, 1880, p. 45.

"Addison's is a large champion lode, with well-defined walls, and certainly is worthy of being explored. . . . . .

"The adjoining claim north (from Golden Age) is the Silver King, with a shaft down 70 feet on the lode, which has penetrated the blue ore, but not rich in silver; and the chloride ores in this mine are not nearly so rich as they were in the Golden Age. This is the most northern point at which the lode has been seen."

Worthy of note also, in the collection, were specimens from the Little Plant Mine, near Emmaville—a larger exhibit from this mine was shown by the Company which was formed to work it, and named the Webb's Silver-mining Company, after the discoverer, Mr. L. Webb—the following description of its nature and occurrence, by Mr. Geological-Surveyor David, will be of interest, it being, as far as I am aware, the first discovery of importance of argentiferous fahlers in the Colony*:—

"The rocks in which the vein occurs are bluish-grey altered mudstones and claystones, passing at points of extreme alteration into white felstone and argillite. These altered palæozoic rocks are cut by numerous cleavage planes running principally 10° to 40° north of east and south of west, while their lines of bedding strike about 20° west of north and east of south, dipping westerly. . . . .

"Rising in places five or six feet above the level of the surrounding country, the silver vein forms a conspicuous wall-like mass as it strikes through these altered rocks. It may here be described as a breccia vein, composed principally of slate rock cemented and hardened by strings and bunches of quartz. The latter seem to have risen up, or segregated, partly along the cleavage planes of the argillite, and partly parallel to the strike of the vein.

"Towards the centre of the vein the cleavage planes of the slate rock may be observed to be much twisted, and occasionally the rock presents the appearance of having been shattered and recemented. There is no sign of walls or of slickensides.

"This mass of quartz-veined slate rock forms the capping of the vein, and can be traced for at least a mile and a half along the surface. Within this distance the reef throws off several branches, some of which die out, while others rejoin the main vein. Its average strike is 3° east of north and west of south, and its dip is about 73° westerly. The width of the main vein and its branches varies from one to six yards, but the metalliferous portion, as far as can be seen on the surface, is nowhere more than 3 feet wide, and is confined chiefly to the centre of the vein. . . . . .

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* Geology of the Vegetable Creek Tin-mining Field, 1887, p. 156.

"The chief ores found in this vein up to the present, are galena, copper pyrites, mispickel, and a variety of grey copper containing silver and a trace of gold (silver fahlerz). The mispickel, which does not appear to be silver-bearing, occurs principally freely crystalized through the clay-slate rock between the veins of galena and fahlers. The latter are associated with quartz and fluorspar. Much of the galena is fine-grained, and has returned silver at the rate of 148 oz. per ton. . . . . . Since the time of my visit the vein has been sunk upon at thirteen different points, and grey copper ore, rich in silver, has been proved to extend downwards for at least 210 feet from the surface. . . . . .

The following analysis by the Government Analyist shows the composition of the argentiferous grey copper :—

	In 100 parts.
Metallic copper	31·500
Do antimony	18·130
Do zinc	6·140
Do iron	6·440
Do lead	·680
Do silver	*1·635
Sulphur	26·180
Insoluble in acids (silica)	7·200
Trace of arsenic, gold, undetermined	2·095
	100·000

* Equal to 534 oz. 2 dwt. of metallic silver per ton.

The fact of the strike of this vein differing from that of the surrounding strata, and of the principal lines of cleavage, accounts partly for the absence of walls and of defined courses of ore, the ores being so much intermixed with the country rock in strings and bunches as to necessitate a great deal of dressing and selecting of the stone for treatment."

The White Rock Silver-mining Company, Fairfield, Drake, exhibited a massive pile of ore from their mine; one large block, weighing about two tons, well represents the character of the lode-stuff, which consists of a quartz and felsite gangue with strings and veins of zinc blende, galena, copper and iron pyrites. In some specimens small bunches of filiform native silver are present. The breaking of the lode-stuff along the course of a vein frequently exposes small cavities in which splendid examples of crystallization of the vein-filling minerals are seen.

The following is an extract from a report on this property by Messrs. Cox and Seavor, mining and civil engineers :—

"The property in question consists of two 40-acre blocks, held as mineral leases from the Government. It is situated at a distance of about 3 miles from the mining township of Fairfield.

"\. . . . The main country rock of the district is a 'porphyrite,' known locally as 'diorite'; and in the White Rock claim a creek has cut through this and exposed, for some distance, a large felsite dyke traversed in all directions by veins, which consist of quartz on the surface, but at a few feet down change to a mixed ore, galena, fahlore, blende, and a little copper pyrites all occurring, and it is in these veins that the silver is chiefly found, although the rock itself also carries small quantities apparently disseminated through it.

"Along the course of the creek the felsite, with ore-bearing veins, has been exposed continuously for a distance of 500 feet, and for 392 feet further outcrops of the same rock have been found below a broken porphyrite, which occurs on the spurs of the hills. Extending back from the creek in a north-west direction the same class of rock is found as far as the boundary line between the White Rock and Pillar's claim, a distance of 583 feet."

"The greatest width of the exposure lies 335 feet back from the south-eastern face along the side of the creek, where it has been proved for a length of 710 feet along this line. . . . .

"Of the ore in sight approximately one-tenth is lode-stuff, or, in other words, there is 71 feet in the width of 710 feet, consisting of vein material, of which the average assay is 215 oz. 6 dwt. per ton on the veins."

The following particulars of bulk parcels of the ore treated have been supplied by the Secretary to the Company:—

PARTICULARS of Ore sent to various Smelting Works and at the Mine, from the commencement to the 28th May, 1888.

Quantity of Ore.				Less Moisture.			Net weight.				Silver.	Price.		Gross value.			Sampling and Smelting charges.			Freight and other Charges.			Net Amount Received for Ore.		
Tons	cwt.	qr.	lb.	Cwt.	qr.	lb.	Tons.	cwt.	qr.	lb.	Oz.	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
7	17	0	15	1	2	8	7	15	2	7	131	3	4 4/13	171	2	4	25	5	7	49	8	0	216	8	8
6	5	2	0	1	1	0	6	4	1	0	136	3	3⅚	140	3	9	20	3	10						
8	18	1	14	5	1	11	8	13	0	3	120	3	2⅚	167	19	5	66	2	5	84	0	0	193	17	4
11	16	1	0	2	1	13	11	13	3	15	94	3	2 3/7	176	0	4									
1	19	3	0	0	3	5	1	18	3	23	177	3	6¼	31	10	6	5	16	11	7	13	3	18	0	4
36	17	0	1	11	1	9	36	5	2	20	658	....		686	16	4	117	8	9	141	1	3	428	6	4

Quantity of Ore.				How Disposed of.
Tons.	cwt.	qr.	lb.	
34	17	1	1	English and Australian Copper Company, Limited.
1	19	3	0	Australian Smelting and Refining Company, Limited, Dry Creek.
0	2	0	8	San Francisco Works.
59	0	0	2	Aix-la-Chapelle Works.
95	19	0	11	
4,250	0	0	0	At Mine.
4,345	19	0	11	Total quantity of Ore.

Particulars of Ore treated from 28th May to 29th October, 1888.

Weight.				How disposed of.	Net Value.		
Tons.	cwt.	qr.	lb.		£	s.	d.
34	6	2	25	English and Australian Copper Company, Limited................	462	12	0
1	18	3	23	Australian Smelting and Refining Company, Limited, Dry Creek..	21	0	0
57	10	0	1	German Works..	724	1	7
93	15	2	21		£1,207	13	7
24	14	1	25	San Francisco Works (Assay Returns only).			
45	0	2	26	Swansea Works, per "Afghan" (despatched October).			
163	10	3	16				

Mr. T. Horton, jun., of Fairfield, exhibited samples of silver ore from the recent discovery at Rivertree, at the head of the Clarence River, about thirty-five miles from Tenterfield, which were estimated to yield 200 oz. of silver per ton and 20 per cent. of lead.

The Webbs Consols Silver-mining Company, near Emmaville, exhibited two trophies of ore from their mine. The ore in the first consisted of a quartz and felspathic gangue with arsenical pyrites, galena, zinc blende, and copper pyrites. The second trophy represented the result of more recent development in the mine, and showed a marked improvement in the ore, a greater percentage of galena being noticeable, and less gangue. 4 tons 17 cwt. of this ore recently treated at Footscray, Victoria, yielded 2 tons 18 cwt. 3 qr. 4 lb. of lead, one ton of which on being desilverised yielded 126 oz. 3 dwt. of silver.

This property is situated on the western bank of the Severn River, parish of Gordon, county of Gough, and is distant from Emmaville about ten miles in a south-westerly direction. The nearest railway station is that of Deepwater, about seventeen miles from Emmaville. The property comprises two hundred and twenty acres.

The following particulars are extracted from a report by Mr. Thomas G. Davey, in the first half-yearly report of the company, just to hand:—"There are five distinct lodes in your property, which are, from all appearances, true fissure veins. They consist generally of porphyry (quartz) traversed by veins of quartz, arsenical iron, copper and iron pyrites, zinc blende, and galena. Their actual width has not yet been ascertained; the outcrops, however, are distinct in places, and, together with trenches which have been made in various parts across the lodes, show them to vary from 10 feet to 35 feet wide. The lodes are enclosed in a porphyritic granite formation, which appears to be general for some miles around, with the exception of an occasional intrusion of metamorphic slate and basalt. . . . . Since work commenced on your property the total amount of sinking done is 230 feet, and that of driving 18 feet. In all cases the prospects have been satisfactory. It will be observed that No. 2 shaft, which is at the lowest level, has produced more galena, and generally richer ore, than any of the others. This fact is very encouraging, as it goes to prove that, as greater depths are attained, more defined, compact, and valuable deposits of silver ore will be discovered. Nos. 1 and 3 shafts as yet show no galena, but I am of opinion that when these shafts have reached the level of No. 2, it will be found that the arsenical iron will have given place to argentiferous galena. This opinion is partly confirmed, inasmuch that a shaft sunk on an adjoining property on the north . . . . to a depth of 30 feet, on No. 1 lode, and at a lower level (about 50 feet), galena is being met with throughout the lode similar to that found at the surface of No. 2 and to that which we are now finding in No. 4 shaft on No. 4 lode."

Assays of the galena gave 95 oz. of silver per ton and 80 per cent. of lead. A bulk sample gave 75 oz. of silver per ton and 22 per cent. of lead.

Mr. Edward Irby exhibited silver ore consisting of galena in claystone, from Pye's Creek, near Bolivia, which was stated to yield at the rate of 100 oz. of silver per ton and 50 per cent. of lead.

The Mascotte Gold and Silver-mining Company, Drake, exhibited quartz and felspathic veinstone, with zinc blende and pyrites, from the lode worked by them, which is reported to be twelve feet in width, and to yield 1 oz. of gold and 100 oz. of silver per ton.

The Gordon Silver-mining Company, near Emmaville, exhibited massive blocks of felspathic lode-stuff with galena, zinc blende, and pyrites.

The Back Creek Gold and Silver-mining Company exhibited a large block of ore from the 40-foot level, No. 2 shaft, where the reef is five feet thick. The lode-stuff consists of quartz and talcose schist. The following description by the Inspector of Mines will be of interest*:—

"In June last the Back Creek silver deposits were inspected by me. These deposits are situated about 6 miles from Rockley, midway between George's Plains and the Newbridge Railway-station on the Western line. At the time of my inspection the works consisted of an open cutting, in which the gold and silver was first discovered, and a drive 60 feet in length to connect the open cutting with No. 1 and No. 2 shafts, the latter of which was 40 feet in depth.

"The silver deposits occur in irregular bunches and lenticular quartz-veins varying in thickness from 4 to 18 inches. Some of these veins contain a high percentage of silver and gold. Although the quartz-veins are thin, the fissure in which they occur is fully 5 feet in thickness, and the matrix between the quartz-veins is said to contain a small percentage of silver. Strike of veins, N. 25° W., with a westerly underlay towards a limestone formation. The general geological formation of the district consists of Silurian sandstone, shales, limestones, and talcose, chloritic, and micaceous schist. . . . .

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* Annual Report, Department of Mines, New South Wales, 1887, p. 111.

"Back Creek is an old gold diggings, on which for years past, both alluvial and quartz were worked with payable results. Owing to the large percentage of silver, the gold realized a low price, which caused the abandonment of the quartz-veins in that district, but on the discovery of the Sunny Corner Silver mines, the Back Creek quartz-veins were retaken for the purpose of testing for payable silver deposits.

"36 tons 18 cwt. 1 qr. of ore was forwarded for treatment to the International Smelting Works, which yielded 3,406 oz. of silver, and gold at the rate of 15 dwts. per ton, which proves that by careful dressing of the ore and economically working the mine, highly payable returns may be anticipated. So far no galena or carbonate of lead have been discovered; but, as the mine has not been extensively opened, it may still be found to contain galena, also carbonate of lead. At present it is impossible to estimate the full extent of the value of the deposits."

The Tuena Silver-field was represented by exhibits from the Mount Costigan, Cordillera Hill, and One Tree Cordillera Silver Mines.

The Mount Costigan Silver-mining Company exhibited soft earthy gossan with carbonate of lead; some large and handsome crystallized specimens of the latter were also shown. The Company also exhibited about half-a-ton of silver-lead bullion, obtained from their ores. The following particulars have been kindly supplied by the secretary, Mr. A. A. Gallagher:—

"The mine is situated at Tuena, county of Georgina, and consists of 125 acres. Smelting was commenced on the 26th July, 1887, and has been continued at intervals since, in the two furnaces erected. The quantity of ore treated was 4,565 tons, yielding 106,084 oz. of fine silver, 659 oz. of fine gold, and 359 tons of lead, of a total value of £26,361. The Company employs upwards of 120 men, and has expended over £40,000 since the formation of the Company. Very extensive additions to the machinery are at present being made, which will greatly increase the output. A new shaft has been sunk to a depth of 100 feet, making in all three shafts. A wire tramway is being constructed to connect the mine with the smelters. The Company has paid £3,750 in dividends."

The Cordillera Hill Silver-mining Company had, as an exhibit, a handsome trophy of their ores surmounted by bars of the silver-lead bullion obtained from them. The ores consisted of carbonate of lead and copper, and sulphides of lead, copper, and iron, in a quartz and ironstone gangue; iron ore and limestone, for fluxing, were also shown in the trophy. In a case alongside were specimens of friable crystalline carbonate of lead, and a quantity of scheelite (tungstate of lime), slightly stained with green carbonate of copper. Several large blocks of ore from this mine were also shown on a table-stand close by.

The One Tree Cordillera Silver-mining Company exhibited a quantity of ferruginous siliceous gossan and schist.

Mr. Warden Smith, P.M., reports[*] that:—

"The district of Tuena has been brought prominently before the public during the year by the rich discoveries of silver ore at Costigan, near Tuena. A company has been formed and smelters erected. Four shafts have been sunk, and 30,000 oz. of silver obtained, valued at about £4,875; also 103 tons of lead.

"Another property was also put into a company, and called the 'Cordillera.' Smelters are being erected; shafts sunk upon the lode. A tunnel driven into the hill has cut the lode, which assays well."

The New Lewis Ponds Gold and Silver Mining Company exhibited a handsome trophy of their ore, reaching a height of about fifteen feet, on which the ores were arranged in the order of their occurrence from the surface to the lowest level attained, 150 feet, at which level the ores pass from ferruginous gossan with carbonate of lead into sulphides of iron and lead. The base of the trophy at about three feet high was surrounded by four glass-cases in which picked samples were shown, consisting of beautiful examples of crystallized native silver, as yet bright and untarnished; chloride of silver, in some instances filiform, and passing at one extremity of the filaments into native silver or *vice versa*; in the cases also were good specimens of carbonate and sulphate of lead crystals, which are very plentiful above the water-level. I append the following description by Inspector of Mines[†]:—

"The Lewis Ponds Mines are situated on the eastern slope of one of the high hills of the Lewis Pond, about 15 miles by road east of Orange, 4 miles south-east of the Old Icely Copper-mine, and 10 miles north of Ophir. The geological formation consists of altered sandstone, micaceous talcose slates, porphyry, and limestone. As far as the lode has been opened, it consists of gossan ore, containing chlorides of silver and carbonates of lead, with a fair percentage of gold. Very little, if any, galena has so far been met with. The lode occurs in bunches from narrow veins to 16 feet in thickness, and its strike is north-west 10° north, with a westerly underlay. About seventy assays have been made, and I was informed with an average yield of 60 oz. of silver, and 1 oz. of gold per ton. . . . . At the time of my inspection three shafts had been sunk, viz., the working shaft 87 feet in depth, with a winze in the north level 29 feet 6 inches, making a total on the lode of 116 feet in depth, and the length opened on the course of the lode was 110 feet. An air-shaft and a main shaft were also being sunk; the latter was 8 feet by 4 feet in the clear, was 50 feet in depth, and intended to strike the underlay of the lode at a greater depth. The ore out of the Lewis Ponds Mine could be raised at a comparatively low cost, owing to the gossan ore and the walls of the lode being soft and require very little blasting. Fully 500 tons of ore were at grass, and several hundred tons of ore were exposed to view in the mine.

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[*] Annual Report, Department of Mines, New South Wales, 1887, p. 49.
[†] Annual Report, Department of Mines, New South Wales, 1887, p. 111.

"About 200 yards westerly of this lode, also in the Company's ground, is a large outcrop of limestone, and about 100 yards westerly of this is another outcrop containing minerals, on which an old shaft has been sunk many years ago, and in which a lode can be seen from 6 to 8 inches in thickness likely to contain both gold and silver."

The Mount Stewart Silver-mining Company, Denison Town, exhibited a quantity of ore from their workings, consisting of gossany ironstone, with carbonate of lead and galena; also in a small glass-case divided into compartments a complete suite of the minerals occurring in the lode.

The Government Geologist, who inspected this locality shortly after its discovery, states in his report that seven gossan lodes have been found, but only on two of them had prospecting been done at the time of his visit. One lode is 45 feet wide, dipping N.N.W. at 45°, and outcropping on the surface for a length of 200 feet. The lode is well defined, and consists of gossan with patches of quartzite and manganese, containing pyrites and sulphide of zinc, in the gossan occur patches up to nine inches thick of carbonate of lead and galena. Six samples taken from different portions of the lode yielded from 10 dwt. 21 gr. to 19 oz. 1 dwt. 2 gr. of silver per ton, and a trace of gold in some. The silver appears to be principally confined to the lead ores, which assayed 76·5 per cent. of metallic lead. Several other lodes from sixteen feet to fifty feet wide, and from 200 to 450 feet long, crop out in the vicinity of the lode described. The Government Geologist was of opinion, though the assays were low, the favourable appearance of the ore at the surface warranted the proper testing of each of the above-mentioned gossan lodes.

Mr. J. G. Griffin exhibited silver, gold, and copper bearing lode-stuff from the Eyrie South Mines, Wiseman's Creek, near Brewongle. The ore consists of rich blue and green carbonate of copper, ferruginous carbonate of lead, and sulphides of copper and lead. The Government Geologist, who examined this lode when it was formerly worked for copper, states:—

"The lode is in talcose schist, which dips S. 79° 45′, W. at 63°; it occupies the fissure of a fault, and strikes N. 15° W., and has a varying dip generally to the east. The ore occurs in bunches along the course of the fault and in off-shoots from it. The bunches and shoots of ore, together with some veins of quartz, are of irregular thickness, being from 1 to 18 feet. The ore is of a very mixed character. . . . It consists of the green and blue carbonates, sulphides, and black oxide of copper, with the sulphides of lead (galena), zinc (blende), and iron and arsenical pyrites; occasionally a little native copper is met with. Occupying, as it does, the fissure of a fault, this lode will doubtless prove to be a permanent one in depth."

The Captain's Flat Silver-field was represented by bulk samples from the Commodore and Vanderbilt Silver Mines, and hand specimens from the Koh-i-noor, the latter exhibited by Mr. C. L. Garland, M.P.

The Commodore ore consisted of yellow ochreous gossan, with carbonate of lead, and the Vanderbilt of porous ferruginous gossan. In the latter ore occur nests of chloride of silver, and assays have yielded very high returns of silver per ton. The samples exhibited by Mr. Garland from the Koh-i-noor Mine consisted of ferruginous carbonate of lead, and copper, and gossan. In connection with the latter mine Mr. Warden Woore, P.M., reports[*]:—

"I am informed that the total quantity of ore raised during the year is 2,346 tons, 2,106 tons of which have been smelted on the ground, yielding nearly 122 tons of bullion, containing, by assay estimates, 40,877 oz. of silver, 364 oz. of gold, 4¾ tons of copper, and 116 tons of lead; also 54 tons of copper matte, containing, by assay estimates, 4,828 oz. of silver, 13 oz. of gold, 15¾ tons of copper, and 8½ tons of lead; and there are from 60 to 100 tons of copper matte, the actual weight and value of which have not yet been ascertained. The remaining 240 tons of ore are now awaiting treatment."

Since the above report, I am informed by Mr. C. L. Garland, over 2,000 feet of sinking and tunnelling have been done in this mine, which has disclosed the presence of several thousand tons of very payable gossan ore, 500 tons of which have been sent to smelters.

Mr. Woore also states[†]:—"At the Vanderbilt Mine. . . . a shaft has been sunk 62 feet, from which a drive has been made W. 25 feet, intersecting a gold, silver, and lead bearing lode, about 8 feet wide, running north and south. About 150 tons of ore have been raised, from which a number of assays have been made locally, yielding, I am informed, from 10 to 180 oz. of silver, and from 1 to 4 dwt. of gold per ton."

In the Commodore Silver-mine, Captain's Flat, according to Mr. Garland:—4,000 feet of tunnelling and winzes have been carried out, all work, except shaft, in ore. Some very rich gold-bearing ore assaying as high as 3 oz. in bulk, with a fair percentage of lead and silver, has been opened up in this mine.

Two hundred and fifty tons of the ore have been sent to the 30-ton smelter, which has been erected in connection with this and the Vanderbilt mine (now amalgamated).

Mr. W. Bridle exhibited silver ore from the Yarrangobilly Silver-mine, Tumut District, consisting of massive galena and carbonate of lead, with traces of carbonate of copper. In this exhibit were some interesting specimens of galena, showing rhombic cavities, from which calcite has been removed.

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[*] Annual Report, Department of Mines, New South Wales, 1887, p. 81.

[†] Annual Report, Department of Mines, New South Wales, 1887, p. 82.

Two parallel lodes occur in this property, one of which has been traced on the surface for about 800 yards, having a width of about three feet. Assays of the lode-stuff yielded from 20 to 98½ oz. of silver per ton.

About eighty yards to the eastward the second lode has been traced for about one hundred yards on the surface; it is twelve feet wide at a depth of twenty feet. Assays of the ore have yielded up to 20 oz. of silver per ton, and from 45 to 80 per cent. of lead. In one instance gold at the rate of 1 oz. per ton is said to have been obtained. Limestone and iron ore for fluxing are abundant, whilst timber of the finest quality is obtainable in unlimited quantity. The adjacent river can be utilized as a very powerful and economical motive power.

Mr. H. W. Jackson exhibited silver ore, consisting of galena in quartz from the Big Badja Silver-mine, Cooma District.

V.—Tin.

The approximate area of the tin-fields in New South Wales is 5,440,000 acres. According to the official report of Harrie Wood, Esq., Under Secretary for Mines, the value of the total production of tin to the end of 1887, amounts to £7,927,876. The tin ore, therefore, ranks next in importance to gold and coal as a source of wealth to the Colony. The existence of tin ore in New South Wales was known for many years, but it was not until 1871 that any attempt was made to turn this mineral to account as a marketable commodity. The most extensive deposits of ore have been found in the northern portion of the Colony, and a large area of country in the Barrier Ranges, in the north-west portion of the Colony, has proved to be stanniferous. Tin ore has also been discovered in other districts. The value of the tin obtained in 1887 was £525,420.

The ore has hitherto been obtained in the beds of water-courses, and it is separated from the gravel by sluicing. In some localities extremely rich deposits of drift tin ore have been found in the beds of ancient streams, at a depth from 60 to 200 feet below the surface. Valuable lodes or reefs have been discovered, and in some places crushing machinery has been erected to extract the ore. The tin-bearing granites of New South Wales belong to the same geological era as those of Cornwall. Many years will elapse before the ground now being worked will be exhausted.

In the Vegetable Creek Tin-field alone only about three miles of the deep leads have been worked out since their discovery in 1873, and it has been estimated that there are forty-six miles in length of deep leads yet to be worked, as shown on the geological map (exhibited) of that tin-field, by Mr. T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor.

In his "Geology of the Vegetable Creek Tin-mining Field," the same author classes the deposits of tin ore as: I, Stream Works, and II, Veins.

"The stream works are subdivided into (*a*) "Shallow Leads," and (*b*) "Deep Leads."

(*a*) The "shallow leads" of Recent and Pleistocene age, are situated chiefly at the source of Vegetable Creek, and consist of loose sand, gravel and rubble, as well as hard, compact sheets of "cement" (a natural concrete formed of fragments of quartz-porphyry, cemented with felspathic material, silica, and oxide of iron). The width of this shallow lead varies from 1 to 5 chains. The "wash" occurs next the bed rock, at a depth of from a few feet to 15 feet from the surface, and averages 1½ feet in thickness. The lead has been worked for 5 miles down the creek from its source, in which distance it has yielded up to date over 20,000 tons of stream tin ore. Most of the stream tin is well rounded by the constant attrition to which it has been subjected for ages by the mechanical action of the water of the creek, while some is still sharp and angular, preserving its original crystalline form. Sub-angular and round pebbles of quartz-porphyry, containing minute veins of tinstone, are frequently found associated with the stream tin, clearly proving that the stream tin was derived from the disintegration of minute veins of tinstone, which traverse the quartz-porphyry at the bottom of the Vegetable Creek valley in such numbers as to constitute a vast stockwork.

(*b*) The "deep leads" are stream works formed in the beds of pre-historic dead rivers, the stanniferous gravels of which have been sealed up under stony sheets of lava and volcanic tuff to a depth of from 100 to 300 feet. These volcanic rocks belong to at least two well-marked periods, and the deep leads are thus subdivided into newer and older, the newer leads frequently containing pebbles of the older lava, and resting on a floor of the same material.

"The geological age of the older deep lead is proved to be early Tertiary by the nature of the fossil plants associated with the stream tin, amongst which are several varieties of beech, oak, and pines allied to the kauri and Wellingtonia, all of which are now extinct in the district, intermixed with banksias, grevilleas, laurels, and eucalypti.

"Some idea may be formed of the richness of these ancient river gravels from the fact that on the Vegetable Creek Tin-mining Company's property 2,000 tons of stream tin were won in an area of 5½ acres.

II. The tin veins, which number in the aggregate over ninety, are classed as—

(*a*) True (fissure) veins.

(*b*) Pipe veins.

(*c*) Stockworks.

The veins belonging to the (*b*) and (*c*) type are small, and as yet have not been worked to a profit.

"The most important veins, such as "The Ottery," "The Dutchman," "Butler's," &c., belong to the (*a*) type. The ore invariably runs in shoots, most of which dip obliquely along the plane of the vein at an average angle of 26° from the horizon, chiefly to the north-east. The average strike of the veins is 39° east of north and west of south. The underlie is chiefly to the north-west, at an average angle of 23° from the vertical.

"The average width of six of the largest veins is 3 feet, and the greatest length to which any one particular vein has been proved tin-bearing is 1 mile, and the greatest depth to which they have been worked over 200 feet.

"The minerals in the veins associated with the tinstone are:—Quartz, chlorite, felspar, mica, mispickel, iron pyrites, fluor spar, tourmaline, wolfram, blende, galena, copper pyrites, bismuth, molybdenite, vesuvianite, stilbite, hematite, pyrrhotine, manganese, scheelite, and beryl.

"The prevailing country rock is granite, but a few of the veins are enclosed in a chloritic quartz-porphyry and in claystone.

"The average yield of black tin from the veinstone, after it has been roughly picked, preparatory to being crushed, is 3½ per cent.

"The total amount of black tin won from the lodes up to date is about 2,000 tons.

The Minister for Mines exhibited a general collection, numbering one hundred and eighteen specimens of lode and alluvial tin ore, from the principal mines in the Vegetable Creek Tin-field, New England, and from other localities.

The following particulars from Mr. Geological-Surveyor David's Report, concerning the lodes, from which specimens were exhibited, will no doubt be of interest*:—

"*The Ottery* veins occur in dyke masses of hornblendic granite and eurite, within 8 chains from the margin of the claystone. The main vein with the cross vein has been proved to be productive of tin for a distance of over ¼ mile, and for a vertical extent of 169 feet. The well-defined nature of the walls, the strong slickensides, and the quantity of clay fluccan lining the veins, proclaim this to be a true fissure vein. It will be noticed that in all cases where the inclination of the vein from the vertical became suddenly lessened, it became pinched and unproductive, confirming the well-known experience of miners that those parts of a vein which most nearly approach the vertical are generally the richest. The strike of the veins follows approximately that of the junction line between the porphyrite and claystone. The dip, except in the case of the west vein, is north-westerly, following the underground line of junction between the crystalline rocks and the claystone, give these ore bodies the character of contact deposits. The ore in these veins occasionally runs in shoots, which dip to the north-east, following, perhaps, the dip of the sedimentary rocks in the immediate neighbourhood. The shooty character of the ore is, however, less observable here than elsewhere. At the time of my visit, 1,200 tons of veinstone from these veins, crushed at Tent Hill, yielded a trifle under 5 per cent. of tinstone, and subsequent crushings have yielded a little over 8 per cent. As soon as the shafts and levels have been sufficiently extended to admit of stoping on a large scale, these mines should pay.

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* Geol. of the Vegetable Creek Tin-mining Field, 1887, p. 143.

"*Butler's* vein has been traced for a distance of 1 mile through portions 173, 174, and 307, parish of Highland Home. . . . . The average strike of the vein is 85° north of east and south of west. The dip is north-west, varying from 72 to 85. The thickness varies from 2½ feet to 10 feet, averaging 3 feet 2 inches. The vein was being systematically opened up from its south-west end for a distance of 10 chains by Butler's Tin-mining Company. . . . . . The casing is eurite, passing into coarsely crystalline porphyritic granite. . . . . The tinstone occurs in seams and bunches, freely crystallized in chloritic quartz.

"*Elliott's* vein in Speare's portion 2A, parish of Annandale, and 149, parish of Highland Home, a continuation of the preceding vein (the Geyser), strikes 35° degrees north of east and south of west, is nearly vertical, and averages 9 inches in width. 6 tons of ore have been won from the vein, which averages 1¼ cwt. of tinstone per cubic yard of vein stuff.

"*Old Gulf Lode.*—The Gulf Stream Company's lodes are situated in portion 23, parish of Muir, county Gough, and in portions 59 and 60, parish of Land's End. . . . . . The main body of ore was worked in portion 63, parish of Land's End, county Gough. The veinstone, in places 8 feet thick, averages 2 feet in width, consisting of chlorites, quartz, and decomposed white felspar; strike 1° south of east and north of west; dip, 72° northerly.

Some remarkably rich shoots of ore have been worked on this property, and are described as follows by Mr. David:—"A shaft sunk at the point shown on fig. 6 (on plan) struck a shoot of ore at a depth of 40 feet from the surface. The shoot, which was from 4 to 5 feet in vertical measurement and about 10 inches wide, dipped aslant the plane of the vein in an easterly direction, 20 feet vertically in a horizontal distance of 49 feet, producing 7 tons of ore. . . . . Another shoot commenced at 8 feet from the surface, and was found to dip east gradually for a distance of 10 yards, where it pitched down at a steep angle. At 12 yards from the point of commencement, and 40 feet below the surface, the shoot was split by a horse of granite, part of the vein branching off in a direction west 35° north. Going east from this point, a very rich course or shoot was struck, perhaps a continuation of the preceding. The top of this shoot was 15 feet below the surface. The shoot itself was 15 feet deep, 127 feet long, and from half a foot to 8 feet wide, producing in that space 229 tons of tinstone, at the rate of 16¾ cwt. per cubic yard." At the 120 and 172-foot levels in this shaft two other shoots were met with.

"*Red Cross Lode* in portion 18, parish of Muir, county Gough, strikes 43° north of east and south of west, dipping 85° north-westerly; average width, 12 inches. The vein consists of nearly solid tinstone, replaced occasionally by quartz and chlorite. The tinstone is black, deep red, resin, and translucent. The ore at the centre of the vein is coarsely crystalline, but becomes finer towards the walls. The footwall shows faint slickensides. The vein is cased by hard quartzose granite. At the bottom of a shaft on the vein, 35 feet deep, the vein was 1 foot in width.

"*Curnow's Vein,* in the parish of Highland Home, county Gough, strikes 40° north of east and south of west, dipping 85° north-westerly. The vein is from 2 to 6 feet wide, averaging 3 feet, and has been traced along the surface for 18 chains. The veinstone is quartz and chlorite, well intermixed. . . . At 130 feet from, the surface the vein was tunnelled 35 feet west and 40 feet east, and was 6 feet wide at the shaft and 3 feet at the ends of the drives, and still tin-bearing.

"*Dutchman Lodes,* the vein known as "No. 1 Dutchman," strikes through portions 165, 166, and 167, parish of Highland Home, in a direction 34° 30′ north of east and south of west for 10 chains, then 38° 30′ for 12 chains, the vein having been traced on the surface for a total distance of 22 chains. The dip is 81° north-westerly, but the vein is vertical in places. The width varies from 3 to 6 feet averaging 4 feet. The foot and hanging walls are well defined, and show slickensides, and the granite casing is soft. The vein stone is principally quartz, with some chlorite. . . . . Several cavities were met with in the vein, 1 foot in diameter, lined with beautifully-formed crystals of clear and smoky quartz, 8 inches long, enclosing crystals of tinstone. . . . .

"No. 2 Dutchman strikes through portions 4A, 3A, and 2A, in the same parish, in a direction 28° east of north and west of south. The vein is 3 feet wide, and tin-bearing for 1½ feet. . . . The average yield of the total amount of ore crushed at these mines at the time of my visit was 3¾% of tinstone.

"*The Walleroo Vein* has been traced for a distance of 1½ miles . . . . in the parish of Highland Home, county Gough. . . . . The vein is from 1 to 4 feet wide, averaging 1½ feet. The vein consists either of a central crack, the sides of which are lined with vein-stuff, merging into granite, or of a veinstone enclosed between well-defined walls. At the north-east end of the workings the vein has good foot and hanging walls, showing slickensides, the veinstone being separated from the hanging wall by a selvage of clay fluccan, 1 inch thick. . . . . The vein-stuff is composed of quartz, chlorite, and mica. . . . The ore is fairly well mixed through the stone, but occurs principally in small veins of quartz half an inch thick, traversing the mass of the veinstone. Seventeen tons of stone from this vein, crushed at Tent Hill, in 1884, yielded 2¾ cwt. of ore per ton. The strong strike of this vein, its great horizontal extent, and the richness of the vein-stuff invite further prospecting.

" *Yankee Veins.*—Three principal veins, so-called, worked in portion 99, parish of Land's End, may be distinguished as west, middle, and east. The west vein, averaging 1 foot in width, strikes 44° east of north and west of south, dip north-west, nearly vertical. Veinstone consists of quartz, chlorite, and tinstone, and is tin-bearing for a width of 2 inches.

"Middle vein, from 1 to 1½ feet wide, strikes north-east. Vein-stuff similar to preceding. Tinstone occurs in large beautifully-formed crystals in the quartz, and is distributed through the veins in the form of a shoot, pitching easterly. . . .

" *East Vein*, averaging 1½ feet in width, strikes 35° north of east and south of west, and has been traced on the surface 4 chains. In a shaft sunk on the reef . . . . at 15 feet from the surface, a large vugh was found 2 feet long, 2 feet deep, and 1½ feet wide, the sides being lined with magnificent crystals of tinstone and clear quartz. In some epecimens the tinstone invests the quartz, while in others it is enclosed in it, showing that the silica and tin must have been in solution simultaneously.

"*Torrington Veins.*—Parish of Annandale, county Clive. The country is a coarsely crystalline granite, composed of triclinic and monoclinic felspar with abundant dark mica quartz, and a little muscovite and hornblende. Near the north-east end of the main vein the granite is fine grained and intersected by veins of eurite, which latter frequently forms one of the walls of the vein. . . The average strike of the vein is 30° north of east and south of west. The veins consist of fine-grained felstone or eurite, fairly soft from the surface to a depth of from 30 to 40 feet, when it becomes very hard. In some cases the veinstone is separated by a sharp line from the granite country, while in others it merges gradually into that rock. Tinstone occurs in disseminated crystals or thin strings in the felspathic vein-stuff, generally running in shoots or floors, the ore being partly black and partly resin; while some of the crystals are quite translucent. . . .

"The north-west branch of the main Torrington vein . . . at 92 yards along its strike from its south-west end, the vein joins the main Torrington vein. A shoot of ore has been worked out of this branch vein, commencing near the surface at the point of junction, in a south-west direction for a horizontal distance of 120 feet, in which distance the shoot dipped 40 feet. . . . A rich shoot was worked here from near the surface to a depth of 135 feet. The shoot pitched 40° east of north and west of south, at an angle of 45°, and was 2 feet wide where widest, averaging 10 inches. The hanging wall was well defined. In part of the workings, an intrusive dyke of eurite formed the foot-wall of the vein. Close to where the cross course of eurite intersects the vein, a bunch of ore was got out of 64 cubic feet of vein-stuff, weighing 13 tons."

The Government Geologist states * that "*Graney's Lode*, in portion 54, parish of Land's End, is a very remarkable pipe-vein in hard granite. At the surface the vein or shoot consisted of an oval-shaped mass of ore with felspar 2 feet long and 18 inches wide; at 20 feet, it is said to have been 5 feet by 2 feet; and at 40 feet, the depth at which I saw it, it was 2 feet 6 inches long by 6 inches wide.

"*Pheasant Creek.*—The tin lodes at Pheasant Creek are similar in their occurrence to those at Ding Dong, consisting chiefly of detached blows of tin-bearing greisen in granite, and near the junction of the granite with metamorphic sedimentary formations."

In addition to the lode tin ores above described from the New England Tin-fields, and which were included in the collection exhibited by the Minister for Mines, the following private exhibits were shown:—

The Wheal Australia Tin-mining Company exhibited a quantity of rich lode tin ore from their mine, parish of Herbert, county Gough, between Cope's Creek and the Macintyre River. The tin lodes on this property, though rich and extensive, have not yet been developed. The company is preparing extensive works for the proper development of the deposits. The tinstone is very evenly disseminated through the veinstone.

The Torrington Tin-mining Company exhibited a large block of vein-stuff very rich in tinstone.

Jones and Party, from the 101-foot level in their mine at Vegetable Creek, exhibited a handsome block of tin-bearing lode-stuff, showing crystallized tinstone on the face.

Mr. Russell Barton exhibited a collection of tin-ores from New England, remarkable for the beauty of the tinstone crystals, many of which are seen investing quartz crystals, and in other specimens the tinstone crystals are seen to be enclosed in the quartz crystals, which as already pointed out, demonstrates the fact of their contemporaneous crystallization from a solution holding both minerals.

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* Annual Report, Department of Mines, New South Wales, 1883, p. 150.

Mr. T. Mills exhibited specimens of rich lode tin ore, from No. 2 shaft, Westminster Lode, The Gulf, N.E., and a handsome specimen of associated tinstone and quartz crystals from a parallel lode to the Yankee lode before described.

Mr. S. L. Bensusan exhibited a block of rich tinstone from the Dolcoath Mine, Glen Creek.

Mr. Kennedy Hill exhibited lode tin ore from the Butler's Mine, already described. Whilst from about 8 miles from Tenterfield, Messrs. Kennedy & Bateman exhibited a very fine-grained siliceous tinstone, which assays at the rate of about 50 per cent of metallic tin.

Messrs. J. E. Kelly, M.P., and A. Delaney exhibited a quantity of ore from the Gumble Tin and Copper-mine near Molong. The Government Geologist who examined this mine, reports* :—

"The lode commences at the junction of granite and altered Silurian shales, and traverses the latter for about 100 yards in a north 30° east direction. It varies in width from 1 to 8 feet, and consists of ferruginous felspathic and siliceous lode-stuff, more or less impregnated with green and blue carbonates, grey sulphide, and red oxide of copper, brown oxide of tin, and magnetite. The tin ore principally occurs in the central and southerly portion of the lode. . . . . In a drive at the 100-foot level on the eastern side of the lode, for a distance of 15 feet, the country rock, altered rubbly shales, with serpentine in the joints, is found to be impregnated with native copper in bright crystalline, small grains and scales; and on the west side at the 60-foot level, the rock, for a distance of 14 feet from the lode, is, in places, stained with copper carbonates. It is thus evident that the rock on both sides of the lode has been more or less affected by the agencies, probably thermal water holding minerals in solution, which formed the lode. The lode contains tin, copper, silver, and traces of antimony and gold."

Mr. Kelly informs me that the result of a trial of a parcel of some tons weight at Parke & Lacy's Works at Pyrmont, was the concentration of the tinstone up to 60 per cent., and the copper up to 15 per cent.

The Barrier Ranges Tin-field was well represented by bulk exhibits from the Mount Euriowie, Euriowie West, Ruby, The Thistle, Trident, Victory, Wee Jim, Albion, Caloola, Cosmopolitan, Cosmopolitan Extended, Jubilee, and Lady Don Tin Mines.

The occurrence of the tin-bearing lodes in this district is described as follows by the Government Geologist.†

"The tin-bearing rocks have been proved over an extent of country about 28 miles long, in a N.N.W. direction, and 3 miles wide; but they are likely to be found over a much wider area, for the same formations are seen throughout the greater part of the Barrier Ranges as far south as Thackaringa. These formations consist of metamorphosed clay slates and mica-schists, intersected by dykes of granite and quartz reefs. Tin ore (cassiterite) occurs in the granite dykes, not as veins, but in black crystals, in size from a mere speck or grain, hardly visible to the naked eye, up to 3 inches in diameter. It is not even disseminated through the granite, but is distributed more or less in patches, with a little ore scattered between them. In fact the cassiterite appears crystallized like the minerals composing the rock—the quartz, felspar, and mica—which occur separately or together, in coarsely crystalline patches in a fine-grained base of the same minerals. Sometimes one or more of these minerals predominate, so that in places the rock is chiefly composed of mica in large flakes, or of mica and quartz, or of mica and felspar, with crystals of tin ore and black tourmaline intermixed. The granite dykes themselves are very irregular in thickness and extent, either in length or in depth. In some instances, as at Lake's Camp, they suddenly widen out for 100 feet or more across, in others they divide into bunches, or form small oblong or boat-shaped masses.

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* Annual Report, Department of Mines, New South Wales, 1886, p. 132.
† Annual Report, Department of Mines, New South Wales, p. 141.

"One of the most regular lodes yet opened is that which runs for about half-a-mile through the Euriowie north portions. In this also the tin is seen to be more regularly distributed through the granite than is usually the case. But even this lode, or granite dyke, which it really is, varies in width from 1 to 18 feet, and runs in breaks, thinning out at intervals, and making again within a few feet on the west side; nevertheless, the lode appears to be sufficiently persistent to be worked on a large scale.

"I was informed that a parcel of 20 tons of it, crushed at the Umberumberka machine, yielded at the rate of 8 per cent. of oxide of tin. The lode strikes N. 13° W., and has a westerly dip; it consists of coarsely crystalline granite with large flakes of mica, and traverses altered mica-schists, which strike north and south. The same lode continues into the Euriowie South Company's ground."

Caloola.—"On the Caloola Company's lode a shaft has been sunk, following the lode to a depth of 75 feet, and showing it to be much the same character as near the surface. Some 8 tons of 50 per cent. ore have been raised during the sinking of the shaft. The lode or granite dyke dips E. 35° N. at 75°; it is from 1 to 9 feet wide, and outcrops on the surface for about 200 yards; the tin ore is in patches through it."

Cosmopolitan.—"Similar tin-bearing granite lodes occur about three quarters of a mile to the N.N.E., in the Cosmopolitan and other mines.

Jubilee.—"One mile in a S.S.E. direction from here are the Jubilee Company's lodes. One, 18 inches wide but thinning out on the north end, consists chiefly of quartz and felspar, with but little mica; the tin ore occurs in patches, containing about 10 per cent of tin ore. Another granite lode, 2 chains to the east is 2 feet 6 inches wide, and has been opened for 6 feet from the surface; only a little tin ore is visible in it."

Victory.—"On the same line of strike (as the Queen Victoria and Prince of Wales United Company's lode) towards the south, other lodes crop out through the Victory Company's ground. Some of these are being prospected, and a shaft 40 feet deep has been sunk in one 8 feet 4 inches wide. This lode strikes N. 10° W., and consists of coarse crystals of felspar, mica, and quartz, with tin ore in patches, which, if worked separately, would probably yield 20 per cent. of ore."

Trident.—"About 4 miles south is the Trident Tin-mine. Here, within a width of 130 feet, the slate formation is traversed by several granite dykes, one 12 feet wide, very micaceous and quartzose in places, with coarse tin crystals unevenly distributed. A shaft 60 feet deep has been sunk, and the shallow alluvial in a small gully draining from the lodes has been surfaced for a few yards, and several bags of "shed tin" obtained."

Albion Mine.—"On the south side of Yancowinna Creek, in portion 95, is the Albion lode of coarse crystalline granite in altered slate formation dipping W. 25°, N. at 80°; it would probably yield 12 to 15 per cent. of tin. A shaft has been sunk 22 feet deep, 100 feet further south a cutting 4 feet deep has been made showing the lode 7 feet wide, with a small patch of tin ore in centre. Near the south-west corner of portion 95 is a lode 25 feet wide showing a little tin and tourmaline; within 10 chains east are a few other lodes; one from 1 to 2 feet thick containing some tin and brown garnets has been opened 3 feet deep; it strikes N. 40° E. in chlorite slate."

Numerous samples of alluvial tin ore from various mines on the principal tin leads in the New England tin-field were included in the general collection of tin ores exhibited by the Minister for Mines. As these "leads" have contributed almost the whole of the tin produced to date, and are being successfully prospected at the present time, it is not deemed necessary to enter into details, as in the case of the tin lodes or reefs which have yet to be successfully worked. The known occurrence in the Colony of almost unlimited quantities of low grade ore should invite the attention of experts to solve the difficulty of low cost dressing and concentration, upon which depend the financial success of the practical development of most of our tin lodes, and especially those of the Barrier Ranges Tin-field.

Amongst the stream tin specimens shown were some tin-stone "nuggets" from Butchart's Mine. As these came from a very peculiar deposit, the following notes by the Government Geologist will no doubt prove of interest.*

"It was in a small gully which runs through portions 9 and 10, parish of Muir, that these remarkable nuggets of tin ore were obtained. One of the nuggets weighed 32 lb. The alluvial in which they occurred was only about 6 feet deep and 2 chains wide, with porphyritic granite cropping out at the surface on both sides, but no lode was discovered, the granite is much jointed, the joints striking N.E. and S.W."

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* Annual Report, Department of Mines, New South Wales, 1883, p. 149.

The Wheal Victoria Tin-mining Company exhibited a quantity of rich tin gravel from their mine, parish of Herbert, county Gough, between Cope's Creek and the Macintyre River. The alluvial deposits on this Company's property are very extensive, and vary from one to four feet in thickness over an area 1,000 yards wide, and yield fully 2 cwt. of clean tin oxide to the ton of wash. A substantial dam, washing plant, and horse machinery are now on the property; and sluicing is regularly carried on. The output equals ten tons per week when in full work.

The exhibit comprised tin-bearing gravel and dressed tin oxide, together with the associated gem stones from the drift, sapphire, oriental emerald, topaz, and zircons; also some very large quartz crystals. The gem stones shown were small, and of no commercial value.

VI.—Copper.

Several copper lodes are being worked in the Colony; the principal ones are the Cobar, Nymagee, Burraga, Mount Hope, Thompson's Creek, and Balara.

According to the official report of Harrie Wood, Esq., Under Secretary for Mines, the value of the production of copper during 1887 was £199,102; together with copper regulus valued at £1,236; and the value of the total production to the end of 1887 amounted to £5,163,352.

The approximate area of cupriferous country in New South Wales is 6,713 square miles.

The Minister for Mines exhibited a collection of sixty-two hand specimens of copper ores from the various mines in the Colony; also bulk samples from the Great Cobar, Nymagee, New Mount Hope, Burraga, Gordon, and Gumble Copper Mines; and 4 tons of refined copper from the Cobar Mine.

The ores from Cobar consist of rich blue and green carbonates, red oxide, grey and yellow sulphides of copper. Of this mine, the late Mr. Lamont Young, Geological Surveyor, reported*:—

"The workings are on what is known as the West Lode. On the surface there appears the outcrops of two adjacent parallel lodes. . . . . . The great characteristic point in the Cobar Mine is the great variation in the width of the lode, namely, from a mere film to 100 feet. This may be explained by the fact that in slate rocks it would be natural for the sides in places to fall together, closing the fissure at some points, but, by this means, keeping it widely open at others."

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* Annual Report, Department of Mines, New South Wales, 1880, p. 262.

The Inspector of Mines states*:—

"The greatest depth obtained by sinking the main shaft is 564 feet, from which level diamond-drill bores have been put down an additional 60 feet, the lode being 40 feet in width, of fair yellow sulphide ore. Stooping is carried out on the 15, 28, 39, and 54 fathoms, and some intermediate levels; but, with the exception of the 54-fathom level, the ores obtained are carbonates, oxides, and grey ores, which average about 16 per cent. of copper. A new discovery has been made between the 29 and 36-fathom level which would average about 14 per cent. But independently of this find it will take years to work out the different copper ores in sight, and known to exist in the mine."

An assay of the refined copper smelted from the above ores gave 99·65 per cent. of copper; 2 oz. 12 dwt. 4 gr. of gold, and 1 oz. 5 dwt. of silver per ton.

The following particulars of the quantity and value of the output from the Great Cobar Copper Mine have been supplied by the Secretary to the Company:—

From June, 1876, to 30th June, 1888—

	Tons.
Ore raised	197,650
Ore smelted	197,580
Refined copper obtained	22,354
Value realized	£1,827,332

Mr. Russell Barton exhibited, amongst others, some exceedingly handsome specimens of rich green and blue carbonates from this mine, together with specimens of the other ores, and native copper.

The ores shown from the Nymagee Copper-mine, forty-two miles south-east of Cobar, consist of earthy blue and green carbonates and grey and yellow sulphides. The metallic copper obtained from these ores is of the purest quality, being remarkably free from injurious foreign metals. An assay of it gave 99·74 per cent. of metallic copper, with 3 dwt. of silver per ton, and no gold.

Mr. Geological-Surveyor Young states†:—Two lodes occur in this property; the main lode striking N. 17° 30′ W., is nearly vertical, and has a width of about 8 feet. The second lode, known as the east lode, strikes N. 18° W. The ores consist of earthy blue and green carbonates, grey and yellow sulphides of copper.

The Inspector of Mines, in his Annual Report for 1884, states that the yellow sulphide ore has been traced through the mine for a distance of about 500 feet, averaging in parts from 10 to 15 feet in width. . . . . . . In Pope's shaft, between the 50 and 70-foot levels, the lode consists of carbonates mixed with earthy matter about 40 feet in width; some of which is rich enough to go direct to the ore-breaker, and the remainder is treated through the crusher and jigger.

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* Annual Report, Department of Mines, New South Wales, 1884, p. 121.
† Annual Report, Department of Mines, New South Wales, 1880, p. 261.

The following particulars of the quantity and value of the output from this mine have been supplied by the secretary to the Company:—

From January, 1881, to 30th June, 1888—

	Tons.
Ore raised	85,100
Ore smelted	84,159
Producing refined copper, realizing	£735,557

The ores shown from the New Mount Hope Copper-mine consisted of blue and green carbonates, grey and yellow sulphides. The Inspector of Mines thus describes[*] this mine, which is situated eighty miles south of Nymagee, forty miles north-west of Euabalong, and seventy miles north of Hillston:—

"The outcrop of copper in the New Mount Hope Mine occurs on the summit of a small hill, a characteristic feature of all the outcrops of copper lodes so far discovered in the north-western district of New South Wales. The geological formation is an altered sandstone (Devonian), with belts of irony sandstone. The lode has a strike of N. 7° 30' E., and has been opened along the surface for about 200 feet in length; it averages in parts 30 feet in width, and has been taken out in open cuttings to a depth of 50 feet. A few feet westerly of the open cuttings a main shaft had been sunk 150 feet in depth, and drives opened at the 100 and 150-foot levels. At the 100-foot level the lode had been driven across for 50 feet, and on the 3rd of March last, the day of my departure, had not reached the eastern wall; the lode, though in parts dreggy, with small horses (blocks of rock) consists of high percentage ores, such as grey sulphides, red and black oxides, green and blue carbonates and silicates, and a small percentage of yellow sulphide."

From Mr. Lewis Lloyd's Burraga Copper-mine was exhibited four tons of rich yellow sulphide ore. The Inspector of Mines has the following report on this mine[†]:—

"The mine is situated on a high range on the Abercrombie Mountains; and *via* Rockley it is about 50 miles south of Bathurst. The country surrounding Burraga has a highly cupriferous appearance, and presents indications favourable to the existence of other copper lodes than those at present at work. The Burraga copper lodes which occur in the Silurian formation, were discovered and first worked about 6 years ago. . . . . . The ore in the Burraga lodes, instead of being found in bunches, as has been generally the case in this district is found in shoots, with a north-east strike. Of these shoots there are several, but the largest so far opened and stopped on is 110 feet in length, the ore averaging from 4 to 9 feet in thickness. The lode contains very little carbonates and oxides, but mainly consist of yellow sulphides, partly intermixed with quartz. The lodes near the surface are very thin, but have so far increased in size and quality as a greater depth has been reached.

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[*] Annual Report, Department of Mines, New South Wales, 1884, p. 126.

[†] Annual Report, Department of Mines, New South Wales, 1884, p. 126.

The Mining Registrar for the Burraga District, in his report for the year, states[*]:—

"Previous to the 1st September last, mining in this division was at a standstill, owing to the low price of copper. Since that date work has been resumed in the Burraga Mine, and at present there are fifty-three men employed, who have raised 1,154 tons of ore, yielding 120 tons of smelted copper; value, £7,200. The mine is worked to a depth of 240 feet, and shows a splendid face of ore; other lodes are also being opened on Mr. Lloyd's land."

The New South Wales Commissioners exhibited ten tons of metallic copper from this mine; it is of first quality and very free from base metals.

The copper ore from the Gordon Mines, Yeoval, which has hitherto been worked for the gold which it contains, has already been described under the head of gold.

The Gumble ore, having a greater value as a tin ore, will be described under that head.

Mr. W. B. Campbell, the proprietor of the Belara Copper-mine, which is situated about thirty miles from Wellington, had an interesting exhibit from that mine, illustrating the varieties of ore, the associated rocks and minerals, and the various stages in the metallurgy of copper, as pursued at Belara. One hundred ingots of metallic copper were included in the display. Firebricks were shown made from material obtained on the property. A schist, used as a lining in the furnace, was shown; this, on assaying, was found to contain several ounces of silver per ton. Indeed, silver in varying quantities must be present in the ores; the metallic copper contains at the rate of 50 oz. of silver per ton.

Mr. T. L. Richardson, of Murrawombie, exhibited a quantity of copper from the Girilambone Copper-mine. It consists of earthy blue and green carbonate of copper.

The late Mr. L. Young, Geological Surveyor, who examined this property before work was commenced, thus described the surface indications[†]:—

"The copper deposit is situated on No. 5, West Bogan Block, near the N.W. corner, and on the summit of a small hill, known as Copper Hill. The lode has a strike N. 18° W., and dips at an angle of 56°. At surface, the lode was 18 feet wide, and composed of veins of quartz, including between them bands of slate and occasional bunches of extremely rich red oxide of copper coated with green carbonate."

The Inspector of Mines, who visited the mine in 1884, says[‡]:—

"Several bunches of ore have been met with in sinking. The first of these deposits was struck at 86 feet from surface, and for about 14 feet contained gossan and ore. At the 100-foot level, a band of ironstone was met with and sunk through for 7 feet in thickness; and at the 122-foot level carbonate and black ores were met with. At the 300-foot level, in a drive 34 feet to the westward of the shaft, black ore and a small percentage of yellow sulphides were driven through; but the whole of these deposits appear to be of a broken nature; at the time of my inspection yellow sulphide ores were discovered in sinking, which, although of good quality, and might be dressed up to 20 or 25 per cent., was, nevertheless, very dreggy, and not payable for hand-dressing, but require crushing and jigging. It, however, proves beyond doubt that numerous copper deposits are scattered through the hill, and that probably as greater depth is reached, and cross-cutting is pushed ahead some of these deposits may form into a solid body of a yellow sulphide lode."

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[*] Annual Report, Department of Mines, New South Wales, 1887, p. 55.
[†] Annual Report, Department of Mines, New South Wales, 1890, p. 262.
[‡] Annual Report, Department of Mines, New South Wales, 1884, p. 120.

The specimens of the richer ores described were included in the Minister for Mines' Collection.

Messrs. Rae and party exhibited grey and yellow sulphides of copper from Apsley, three miles south of Wellington.

Mr. D. Ferguson, M.P., exhibited a quantity of ore from a copper mine close to the town of Wellington. The ore consisted of grey sulphide with traces of carbonate, and was of low grade.

Interesting hand specimens of copper ores, from various localities in the Colony, were also included in the splendid collections of Professor Liversidge and Mr. Isaacsohn.

VII.—Antimony.

Antimony has been found in numerous parts of the Colony. The principal lodes occur in the Macleay, Armidale, Clarence, and Cudgegong Districts. The lodes near Armidale are payable auriferous. The value of the antimony exported to the end of 1887 was £67,239.

The Minister for Mines, in addition to the bulk exhibit of auriferous stibnite (sulphide of antimony) from the Eleanora Gold and Antimony-mine, Hillgrove, near Armidale, exhibited a collection of thirty-one hand specimens from the different localities in which antimony ores occur in the Colony.

The occurrence and character of the Eleanora lode has been described by the Government Geologist, and his description has been given under the head of gold, as the presence of the latter metal gives this deposit its chief value.

The Macleay River district antimony deposits were described by the late Mr. L. Young, Geological Surveyor, as follows[*] :—

"The antimony deposits are situated on the Munga Creek, 4 miles above its junction with the Macleay River, and occur in rocks which, judged from their lithological character, are of Devonian age. In the neighbourhood of the mines, the strata have been highly disturbed, causing the country to assume a broken character, a point which, taken in connection with variation exhibited in the strike of the lodes, and the frequent appearance of "slickensides," may be considered as favourable to the presence of mineral deposits of an irregular nature.

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[*] Annual Repor Department of Mines, New South Wales, 1880, p. 250.

"The antimony ore occurs in irregular bunches, occasionally of considerable size, enclosed in a quartz matrix, which forms the chief constituent of the lodes. The ores consist of stibnite (sulphide) and cervantite (oxide). The stibnite is of a high degree of purity, and the cleavage faces of crystals are remarkably large and brilliant."

Messrs. Lark & Sons, Moore-street, Sydney, exhibited a large trophy from their Carangula Antimony-mine, Macleay River District, consisting of antimony ore, star antimony, regulus, &c.

In the Departmental collection were samples of rich cervantite (oxide of antimony) from Ford's Creek, near Gulgong. Messrs. J. R. Bingle & Co., of Macquarie-place, Sydney, also exhibited from this locality a large block of similar ore, which assays upwards of 70 per cent. of metallic antimony. The Government Geologist who inspected this lode shortly after its discovery, states* :—

"At the head of Ford's Creek, 6 miles south of Gulgong, three small breccia lodes, or short 'blows,' containing sulphide and oxide of antimony and a little quartz, have been opened to a depth of 5 feet. They occur in irregular fissures formed where the strata (Silurian clay-slates and sandstones, S. 10° E. at 25 feet) have been fractured. The antimony ore occurs in irregular bunches, and as it is impossible to determine the extent of the rupture of the strata without sinking upon it, the probable value of the lodes can only be ascertained by actual prospecting."

In the Clarence River District, on the Yulgilbah Station, are fair lodes of antimony sulphide. Mr. Geological-Surveyor Pittman, who examined them in 1880, is of opinion that they will be well worth prospecting in the future, but until railways have been constructed the means of carriage are too imperfect to admit of their being worked at a profit.

The Cudgegong antimony deposits are thus described by the Inspector of Mines† :—

"The Rockwell antimony-mines are situated about 4 miles north-west of Rylestone, and 8 miles easterly of Cudgegong, near the Cudgegong River. These deposits occur in the slate formation, and are surrounded by metamorphic and micaceous rocks. The ore is associated with quartz, which forms irregular veins underlying west, some of these veins varying from 3 inches to 4 feet in thickness, containing a high percentage of antimony. . . . . Very little work has been done on these lodes, but being so very near the Rylestone railway these antimony lodes are almost sure to be worked extensively, provided the price of antimony will rise in the market."

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* Annual Report, Department of Mines, New South Wales, 1886, p. 136.

† Annual Report, Department of Mines, New South Wales, 1884, p. 124.

Hand specimens were also shown from Rocky River, New England; Caledonian Reef, Nundle, Lunatic, Peel River; and Razorback, near Ilford—the latter being auriferous, is described under the head of gold.

VIII.—Bismuth.

Bismuth ores have been found in the tin-bearing drifts, and also in lodes at Silent Grove, The Gulf (in the Vegetable Creek District), Kingsgate, and Hogue's Creek, near Glen Innes, Elsmore, Tenterfield, Adelong, Mount Gipps (in the Barrier Range, and Gumble in the Molong District; and quite recently near Captain's Flat in the Molonglo District, where it occurs in the form of tetradymite (telluride of bismuth).

The value of the bismuth produced to the end of 1887 was £20,575 14s.

The only bismuth deposits at present being worked are those which occur at Kingsgate, about sixteen miles east from Glen Innes. The Government Geologist who examined them in 1883 gives the following account of their occurrence*:—

"The formations here are granite and altered slate, forming rough broken country, with valleys about 500 feet deep. The line of junction of the two formations is well defined, and the bismuth lodes occur in the granite in proximity to this line, or within about 400 yards from it.

"The mode of occurrence of these so-called 'lodes' is very remarkable. They are pipe-veins or oval masses of quartz of variable thickness, descending in a more or less vertical direction in the granite, as though well-like caverns of very irregular diameter had been formed in the granite, and filled with quartz and metallic minerals. Thus in one lode in the Kingsgate Company's property two masses of quartz (which the manager, Mr. Yates, informed me were 30 feet apart on the surface), on being followed down, united and formed one large pipe-vein about 27 feet in diameter, and of irregular shape, from portions of it protruding here and there into the granite. Nests or bunches of bismuth ore (native bismuth, sulphide, carbonate and oxide of bismuth) were obtained about these protruding portions as well as through the mass of the quartz, and in order to take out the veinstone a large excavation about 60 feet by 40 feet has been made. The vein has only been sunk upon to a depth of 50 feet. The quartz is of a coarsely crystalline nature, and contains, in patches, a considerable quantity of molybdenite. The metallic bismuth and sulphide occur in the solid quartz, but the carbonate and oxide lie chiefly in the joint fissures in the quartz. Sometimes masses of native bismuth are found between crystals of quartz in the vein, and when removed the impress of the quartz crystals is well shown. . . . . The largest mass of native bismuth found here weighed nearly 30 lb.

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* Annual Report, Department of Mines, New South Wales, 1883, p. 154.

"Other similar veins, but smaller, have been proved, though only for a few feet in depth. . . . .

"On portion 25, about half a mile north-west from here, another large pipe vein is being opened; near the surface it consists of a very ferruginous mass of quartz, about 13 feet by 9 feet, containing bismuth, arsenical pyrites, wolfram, and molybdenite. The screened vein-stuff is said to yield about 50 lb. of bismuth per ton. . . . . A sample of the ore, consisting of mixed particles of native bismuth, carbonate, sulphide, and oxide, yielded on assay—

Metallic bismuth	69·3 per cent.
Fine gold, at the rate of	4 oz. 1½ dwt. per ton.
Fine silver, at the rate of	57 oz. 3 dwt. per ton.

. . . . . Several veins of a similar nature have been opened on the Glen Innes Company's property, which adjoins that of the Kingsgate Company. . . . About 3 miles from the Yarrow Head station, and about the same distance in a south-easterly direction from Kingsgate, is the Comstock Bismuth Company's mine. . . . . A sample of bismuth collected from the heaps gave on assay—

Metallic bismuth	35·6 per cent.
Fine gold, at the rate of	2 oz. 9 dwt. per ton.
Fine silver, at the rate of	9 oz. 16 dwt. per ton.

"Thus, again, we see that the bismuth ore contains gold. These veins are in granite, and distant about 200 yards from the slate formation.

"It is a somewhat remarkable feature that all the bismuth veins (eighteen) as yet found, occur in the granite within a short distance from the slate; and it is probable that on further examination of the country along the line of junction of the two formations other veins will be discovered. The bismuth lode in the Silent Grove Mine occurs under the same conditions, viz., in granite, close to its junction with altered slates; and it is of similar character to those described.

"I may here mention that about 12 miles north from Glen Innes, and about 1 mile east from the Tenterfield road, several bismuth and tin-bearing quartz veins have been discovered. These occur in a different manner from those at Kingsgate. They form irregular veins and masses of quartz, traversing a fine-grained micaceous felsitic rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length of about 100 yards and a width of 15 yards, is traversed by a net-work of quartz veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore (cassiterite), molybdenite, arsenical pyrites, and wolfram.

". . . . I do not consider that the vein-stuff there can be profitably worked for tin on account of the occurrence in it of so much wolfram; but for bismuth mining the prospects are encouraging, and the reefs should be further tested."

The Minister for Mines and the Hon. E. Vickery, M.L.C., each exhibited bismuth ores from the Kingsgate mines. Mr. A. Delaney exhibited carbonate of bismuth in felspathic veinstone from Gumble, near Molong. This ore yields about 3 per cent. of bismuth, and the locality is favourably spoken of by the Government Geologist for the occurrence of bismuth ores, as it closely resembles the Kingsgate country.

IX.—Iron, Manganese, Chromium, and Cobalt.

Important deposits of iron ore are found in close proximity to coal and limestone in several parts of the Colony. Furnaces, rolling mills, &c., have been erected at Eskbank, Lithgow Valley, for the conversion of pig iron into malleable iron. Hæmatite, magnetite, chrome, and other iron ores were shown in the mineral collection. The ore found at Mittagong, in the Southern District, contains about 66 per cent. of iron*. The late Rev. W. B. Clarke was of my opinion that the masses of iron ore in this district had been gradually deposited from springs discharging the ferruginous water with which they were charged into a swampy depression of the surface, and remarked that even now the deposit at Fitzroy retains, in part, its original position. Careful examination of the ore revealed the presence of portions of vegetable matter, and tubular cavities, which, no doubt, are the casts of the plants that grew in the swamps.

From the transmuted appearance of the sandstone and shale near the southern edge of this deposit, Mr. Clarke was of opinion that the springs might have been at one time hot. The igneous rocks of the Mittagong district being highly charged with iron, were regarded by the same gentleman as the source of the iron itself; the deposit arising from its decomposition probably took a very long period of quietude to produce a mass at least 27 feet thick, and covering a considerable area.

The process by which these deposits have been formed is still going on wherever a spring or flow of water traverses rocks containing iron, these chalybeate waters on exposure to the atmosphere, absorb oxygen, forming insoluble oxides of iron and liberate carbonic acid. Such springs can be readily recognized by the thin iridescent film on their surfaces, and the rust—oxide of iron—which covers their bottoms. Speaking of the deposits of iron ore at Wallerawang, Professor Liversidge says: †"They contain two varieties of iron—magnetite, or the magnetic oxide of iron, and the brown hæmatite or goethite—the hydrated oxide; then in addition to these there are the deposits of the so-called clay bands which are interstratified with the coal-measures. These clay bands are not what are usually known as clay iron ores in England. They are brown hæmatites, var-limonite, while the English clay iron ores are impure carbonates of iron, which seldom contain much more than 30 per cent. of metallic iron, against some 50 per cent. contained by the hæmatites. A highly ferruginous garnet rock accompanies the veins of magnetite; this garnet rock is very rich in iron, and it will probably be found advantageous to smelt it with the other ores, not only on account of the large percentage of metal which it contains, but also on account of the increased fluidity it would impart to the slag." The approximate area of iron ore deposit is 1,400 square miles. The value of the iron raised to the end of December, 1887, amounts to £265,464.

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* The Government Geologist in "Mines and Mineral Statistics," 1875 (p. 94), states that "so far as could be ascertained some 3,000 tons of calcined ore from the Fitzroy Mine (Mittagong) gave 2,394 tons of pig iron, which sold at an average for £6 per ton. The iron ore is said to be a very fine quality, but somewhat difficult to smelt."

† Minerals of New South Wales, 1888, p. 87.

The Minister for Mines exhibited a collection of samples of iron ores from the principal deposits in the colony; and about a ton from the Fitzroy Iron Mines, near Mittagong; and a similar quantity of chrome iron ore from Nundle, Peel River.

Large deposits of manganese oxide and chromite have been found, but they have not yet been systematically worked.

X.—*Mercury.*

Cinnabar (sulphide of mercury) was shown by the Minister for Mines, from Cudgegong, with samples of the drift in which it occurs. The Government Geologist, who inspected this locality* says, that it occurs in a water-worn quartz pebble drift, and red ferruginous clays, with irregular masses of brown ironstone. This drift deposit he describes as the remains of the old bed of the streams which in the Tertiary period flowed down the Cudgegong Valley, the present river channel having been subsequently eroded.

Mr. Waters, manager of a company, who prospected the deposit some time before, informed him that he sank a prospecting shaft 208 feet, when it was abandoned. He states that the cinnabar was found more or less through the drift, from the surface to a depth of 50 feet on to a false bottom, and that the deposit without cinnabar continued to 117 feet, when the true bed-rock (Devonian schists) was met with; but at 170 feet, when in black schists, he cut through a vein four inches thick, dipping south-west, and containing a little cinnabar. The cinnabar taken from here occurs usually in sharp angular pieces, from half-an-inch in diameter down to the size of fine dust, and pieces have been obtained several pounds in weight. Often the surface of the cinnabar is somewhat rounded, but this may be the original form, and not due to attrition. Perhaps the most important feature connected with the occurrence of the ore is, that the solid cinnabar is sometimes seen to gradually merge into, or impregnate the clay or drift of the deposit in which it is found. This is, then, direct evidence that it has not been drifted by running water, like the water-worn pebbles and other material forming the old Tertiary lead, and that it has probably been derived from thermal water, which issued from the underlying Devonian rocks, and permeated the Tertiary deposit.

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* Annual Report, Department of Mines, New South Wales, 1884, p. 152.

XI.—Tungsten.

Wolfram (tungstate of iron and manganese) and scheelite (tungstate of lime) were shown in the Minister for Mines' Collection, the former from Hogue's Creek, near Glen Innes, and Vegetable Creek, and the latter from Hillgrove, near Armidale, and Cordillera Hill, Tuena.

The Hon. E. Vickery, M.L.C., also exhibited wolfram from New England.

The Government Geologist mentions its occurrence in considerable quantity at Hogue's Creek, about twelve miles north of Glen Innes: and Mr. Geological-Surveyor David made the following report* on its occurrence in the Vegetable Creek Tin-field.

"An important vein of wolfram occurs in the Mole Table-land, 13½ miles north of Emmaville, in a direct line, but 21 miles distant by road. The point at which the reef was observed to be rich in wolfram bears west 36° south from the south-west corner of portion 407, parish of Rockdale, county Clive, one quarter of a mile distant, and lies just outside the boundary of this parish in the north-east corner of the parish of Flagstone, county Gough. The vein is, in places, from 10 to 12 yards wide, though probably not metalliferous throughout its entire width. Owing to the reef being partly covered over by the iron-stained sandy soil, it is impossible to ascertain by mere inspection the average width or length of its outcrop, though surface indications favour the supposition that the reef is a strong one. The strike is about N. 40° E. As far as I am aware, this reef has never been prospected, and it is situated partly on Crown lands. Wolfram also occurs at the Gulf main vein, Hall's Grampians, Lee's Gully, and the Planet vein, near the head of the Nine-mile Creek, parish of Wellington Vale, county Gough."

In 1881 the price of wolfram in England was £10 per ton. In 1882, the total quantity of wolfram raised in Cornwall, England, was 58 tons, which was sold at the rate of £12 17s. 7d. per ton. At the end of March, 1885, the value of wolfram in England, as I am informed by Mr. W. A. Dixon, F.I.C., F.C.S., was about £15 per ton. Scheelite has been found in small quantities at M'Donald's veins, on the Glen Creek, Vegetable Creek District; at Hillgrove, near Armidale, and at the Cordillera Hill Silver-mine, Tuena, a quantity from the latter was shown by the Cordillera Hill Silver-mining Company. The value of this mineral is about £40 per ton.

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* Geo., Vegetable Creek Tin-field, 1887, p. 161.

XII.—Zinc.

The Minister for Mines exhibited specimens of sulphide of zinc (sphalerite) from New England. Mr. Geological-Surveyor David states that zinc has been found in some quantity in the Vegetable Creek District, in the Pye's Creek veins, the Little Plant vein, the copper vein, in Portion 85, Strathbogie North, at Hall's Grampians, and in small quantities in the M'Intire, Butler's Ottery's, and the Folkestone veins. The value of the ore is about £7 per ton.

Calamine (carbonate of zinc) is found associated with silver ores in the Broken Hill District, samples of which were to be seen amongst the exhibits from the Broken Hill Mines. It was discovered at Bredbo, in the Braidwood District, assaying 50 per cent. metallic zinc. A shaft was sunk upon it, but I understand that it pinched out. No workable deposits have yet been found.

XIII.—Diamonds and other Gems.

Diamond-mining in New South Wales is likely to become of much importance. Upwards of 50,000 diamonds have been obtained up to the present time, chiefly from the Tertiary drifts in the Bingera, Inverell, and Cudgegong Districts, besides a few from the neighbourhood of Mittagong, Wellington, and Uralla.

Geological maps of the diamond-bearing localities near Inverell and Bingera, by the Government Geologist and Mr. Geologist Surveyor Anderson, are published in the Annual Report, Department of Mines, 1887.

The principal minerals associated with the diamonds are gold, garnets, woodtin, brookite, magnetite, ilmenite, tourmaline, zircon, sapphire, ruby, admanatine spar, barklyite, common corundum, and a peculiar lavender-coloured variety of quartz, topaz, and nodules of limonite.

The largest diamond weighed 16·2 grains, or about 5⅝ carats.

A diamond from Bingera, used in one of the Government diamond drills, bored 1,267 feet through sandstone and conglomerate, without fracture.

The following extract is from the Government Geologist's report on the diamond-bearing formations in the Inverell district*:—

"The diamond bearing formations on the south side of Cope's Creek, where the Round Mount, Crown Jewel, Kohinoor, Red Hill, and Collas Hill Diamond Mines are situated.

"The diamond mines occur in old Tertiary river drifts, and in the more recent drifts derived from them. The former were once, and are partly still covered by basalt, which, in a molten state, flowed down the ancient valleys, and filled up the river channels. But the enormous denudation which has since eroded the present deep valleys has swept away considerable portion both of the lava streams and of the old river deposits beneath them, leaving the remnants here and there in disconnected patches, resting on the older granite and altered sedimentary rocks. It is in one of these isolated patches that the above-mentioned companies, with the exception of that at Cellas Hill, are working by sinking and tunnelling. The deposits are extensive, and have not yet been thoroughly prospected; the wash-dirt is from a few inches to 5 feet in thickness, and has yielded on an average from 2 to nearly 4 carats per load, averaging about four or five diamonds to the carat, though diamonds between 2 and 3 carats in weight each have been found. The returns kindly furnished me by mining managers show that about 23,000 diamonds weighing 5,151 carats, have been obtained during the last twelve months.

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* Annual Report, Department of Mines, New South Wales, 1887, p. 141.

"The original matrix of the diamond in this country has not yet been conclusively ascertained. The Tertiary deposits are the oldest deposits in which the diamond has been found. Based upon this fact, an opinion was some years ago expressed by myself and others that the diamond may have been formed chemically in those drifts. Extended observations in the diamond-bearing districts would, however, lead me to suggest that if the Tertiary drifts be not the original matrix of the diamond, possibly its source may be in the metamorphosed Carboniferous or Devonian beds, where these have been intruded by granites and porphyries. Evidence of carbonaceous rocks having been subjected to great heat and pressure is presented in the rocks quarried for road metal at Pennant Hills, near Parramatta. If such condition be favourable for the occurrence of the diamond, this locality should be prospected."

Of the Bingera diamond deposits, Mr. Geological-Surveyor Pittman reported *:—
"The diamond drift, probably of Pliocene age, which is from 3 to 4 feet thick; is found capping small hills, the country since its deposition having been subjected to much denudation, which has almost entirely removed the basalt that once covered up this old river bed. The pebbles of the diamond drift vary in size from the size of a pea to several inches in diameter.

"The main dividing range forming the watershed between the rivers Gwydir and Horton, consists of altered slates and conglomerates of Siluro-Devonian age, with intrusive dykes of diorite, above which is another quartz pebble drift (probable Miocene) capped with older basalt which forms a table-land on top of the mountains. The banks of the river Gwydir are also covered with a coarse pebble drift, similar to that in which the diamonds occur, and covered in a few places with newer basalt, but this has been for the most part removed by denudation, and the river has subsequently cut its present channel. The evidence of the older basalt capping the drift on the range of mountains, indicates that this drift is of greater age than either the drift in which the diamonds have been worked, or that along the course

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* Annual Report, Department of Mines, New South Wales, 1881, p. 141.

of the river, the two latter appear to junction, and were probably contemporaneous. It is reasonable to assume that diamonds will be found both in the drift along the banks of the Gwydir, and also under the basalt along the top of the mountain range, since the formation in which they have already been found, is an old river-bed leading from the drift on the top of the range and junctioning with the other drift on the banks of the Gwydir."

The following are the conclusions arrived at by Messrs. Thos. Davies, F.G.S., and R. Etheridge, junr., who, at the request of the Agent-General for the Colony, examined a parcel of 285 stones, forming an exhibit at the Colonial and Indian Exhibition, 1886*:—

"1. The diamonds of New South Wales in their physical character are more nearly allied to those of Brazil than any other country.

"2. They have been very largely sold in London as such.

"3. As regards colour they differ practically but little from those of other fields.

"4. The general absence of 'cleavage' and 'macles' is a point much in their favour.

"5. Stones of the rarer colour assumed by the diamond should be particularly sought for.

"6. The greater hardness of the New South Wales gems will probably raise the cost of cutting, but this will be compensated for by their extra 'brilliancy.'

"7. 'Boart' should be eagerly sought for.

"8. Detailed statistics of the area and thickness of drifts likely to prove diamondiferous, and the number hitherto found so, should be prepared officially.

"9. All auriferous drifts should be prospected for diamonds.

"10. The matrix of the diamond in New South Wales bears no resemblance to that at the Cape."

Samples of the diamond-bearing drifts from the Inverell and Bingera deposits were shown by the Minister for Mines.

The Sydney Diamond Company from their property, twelve miles south-east of Inverell, and close to Cope's Creek, exhibited 400 carats of the usual character of New South Wales diamonds. From this property also were shown samples of the pebble drift (tailings) consisting of rolled pebbles of quartz, agate, and chalcedony, and a few small topaz, and of the waterworn prisms of black tourmaline which is so characteristic an associate of the diamond in these deposits. Stream tin also occurs in the drift.

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* Annual Report, Department of Mines, New South Wales, 1886, p. 42.

Mr. E. W. Bathurst, from the Round Mount Diamond-mine, fourteen miles from Inverell, made a most interesting display of blocks of the drift, as well as loose drift. In one of the blocks and in a small piece broken from them, a diamond in each case could be seen partly exposed. The drift is of a very friable nature and easily worked. A number of diamonds were included in the exhibit, several of which have been cut, and are exceedingly brilliant stones of excellent quality. Specimens of associated gems and minerals from the drift were displayed, viz., topaz, sapphire, &c., stream tin ore and rolled tourmaline; and fragments of fossil wood and loose stones from the surface.

The following particulars concerning this mine have been supplied by Mr. Bathurst:—Area, 150 acres. Average thickness of drift, three to five feet. 2,700 diamonds, weighing 700 carats, were obtained at a cost for wages of £150. 1,500 diamonds, weighing 500 carats, were obtained from forty loads of drift. 408 diamonds, weighing 101 carats, were obtained from seven loads of drift. Over 2,000 carats of diamonds were obtained during the preliminary prospecting of the mine.

The Malacca Diamond and Tin-mining Company exhibited diamond and tin-bearing gravel, quartz crystals, pebbles, &c., from their property in the Inverell District.

As illustrating the occurrence of gem-stones and their associations in the Colony, the splendid collection shown by Professor Liversidge, of the Sydney University, was especially interesting and valuable. It embraced diamonds (some of them most beautifully crystallized) from the Bingera, Inverell, Cudgegong, and Mittagong diamond deposits. Cut and uncut oriental emeralds, sapphires, topazes, zircons, and opals; specimens of the gem sand, drifts, and associated minerals from the above localities; from the Berrima and Uralla districts, and from New England generally. Specimens from the diamondiferous deposit at the Cape were also shown for comparison.

The following particulars of the occurrence of the diamond near Mittagong are taken from the catalogue of Professor Liversidge's specimens:—

"The diamonds are of very good colour and quality, but no large ones have yet been discovered. The deposits have a very great resemblance to those of Bingera, except that tourmaline and the nodules of limonite and magnesite do not appear to be present. . . . . . The deposit covers but a small area; it overlies and is surrounded by the Hawkesbury sandstone. It is not improbable that the gold and gems have been derived from the Carboniferous conglomerate."

Small samples of topazes, sapphires, zircons, spinels, &c., chiefly from New England, were included in the collection exhibited by Mr. Martin Isaacsohn, of Nundle.

XIV.—Alum.

Prior to the recent discovery of alum-stone at Bulladelah, its occurrence in commercial quantity was not known in the Colony; alunogen (hydrous aluminium sulphate) occurring as an efflorescence in certain caves, such as the Ben Bullen had been noted.

The Australian Alum Company exhibited alum crystals prepared from the alunite (sulphate of alumina) obtained from their property at Bulladelah. It occurs as an immense deposit forming the summit of a ridge about three-quarters of a mile long by half-a-mile wide, and rising about 1,000 feet above the level of Myall Creek, on which it is situated. Viewed from the creek it presents a massive outcrop resembling limestone. It yields from 60 to 80 per cent. of alum upon roasting, lixiviating, and evaporating. Myall Creek is navigable to vessels drawing five feet six inches, and its channel is shortly to be deepened by dredging. The company have erected extensive works for preparing the alum, which will shortly be placed on the market.

Mr. A. De Mestre exhibited specimens of alunogen from the Shoalhaven district. It is of common occurrence in shales, and argillaceous sandstones containing iron pyrites—especially if in coal regions. The oxididation of the pyrites affords sulphuric acid, which combines with the alumina of the shale and clayey sandstone.

XV.—Building Stones, Marble, Serpentine.

Almost every variety of building stone may be obtained in New South Wales. In and around the city of Sydney there are numerous quarries in the sandstone of the Hawkesbury formation. This sandstone, which for colour and texture can hardly be surpassed for building purposes, is the stone most commonly used in the construction of the public and private buildings in Sydney. A large collection of one foot, and six inch, cubes of sandstone from the different quarries at work, were exhibited by the Minister for Mines. Extensive deposits of marble, of Silurian and Devonian ages, occur in several places in the Colony. The black variety from the Marulan, and the white from the Cow Flat marble quarries, have been used in flooring the great hall of the Sydney University. The marble near Wallerawang is thus described by Mr. C. S. Wilkinson, L.S., F.G.S., Government Geologist, on his geological survey map of the Wallerawang and Bowenfels District:—

"Thick beds of coralline limestone of very pure quality. It forms a compact marble of various tints—white, cream, and dove-coloured, and sometimes with pink markings. It dresses well, takes an excellent polish, and may be obtained in blocks of almost any required size and quantity. Situated as it is, only 7 miles from the Wallerawang railway station, it will be available for the iron-smelting works in the district, and will afford a source of large supply for the Sydney market. The limestone consists almost entirely of corals—*Favosites gothlandica, Favosites polymorpha, Lithostrotion*, and others, and molluscs as yet undermined."

The red marbles from the Tamworth District are very handsome when polished, and suitable for ornamental purposes. Several large polished slabs of the above marble as well as a number of tiles were exhibited by the Minister for Mines, and a very handsome black and white coralline marble was shown by Mr. J. Burns, from near Rockley.

Granite occurs in great abundance, and in every variety of texture and colour; it is used in Sydney for building and decorative purposes. Specimens from Moruya, Montagu Island, and Trial Bay were exhibited in the Mines collection.

Roofing slates of excellent quality have been obtained in the Goulburn, Bathurst, and Gundagai Districts.

Fine-grained siliceous sandstone, very suitable for flagging purposes, occurs in the Orange, Burrowa, and Narrandera Districts.

Serpentine of pale and dark green colour, sometimes mottled with white, forming a fine ornamental stone, can be obtained in quantity in the Bingera, Grafton, and Young Districts. Polished samples of excellent quality were shown from Bingera.

Syenite from Mittagong was exhibited; it was used in the construction of the piers of the railway bridge over the Hawkesbury River, as being most suitable for resisting the destroying action of sea-water.

The following particulars have been kindly supplied by Mr. W. M. Lewis, Clerk of Works, East Maitland, concerning the collection of building stones exhibited from the Hunter River District; and are the results of practical experience:—

"The Clarence Town sandstone exhibited is very strong and durable; retains its colour; withstands the effect of sea air. Blocks upwards of 10 tons each were used in the erection of the buildings near West Maitland for the Hunter River Water Supply; it was also used in the erection of the Court-house at Dungog, and in the additions to the post office at Newcastle, and I am not aware of a single stone in any of the buildings in which it has been used showing the slightest signs of decay.

"The East Maitland stone has the appearance of durability. It was used in the erection of St. Peter's Church at East Maitland.

"The Wollombi pink sandstone is a good durable stone easily wrought and retains its colour; it was used in the erection of the Public School and master's dwelling at Wollombi.

"The light brown sandstone from the same place is of similar quality to the pink, and as durable; used in the masonry of the Court-house, and would, if it could be conveyed by rail to Newcastle, Maitland, Singleton, &c., do away with the delay which contractors and others are now put to in having to wait time after time for a supply from Sydney, which is usually conveyed by water in sailing vessels.

"Some of the Morpeth stone is very durable, but care must be taken to reject any of a blue or grey tint, which on exposure turns green, and peels off in flakes; it was used some thirty years ago in the construction of bonded stores at that place, and shows no signs of decay.

"The Ravensfield stone is used in the erection of buildings in the Maitland district; it is good stone for ornamental work if kept dry and well above the ground, and care taken to avoid all yellow tints or streaks in the stone, which, if exposed to a north or westerly aspect, will decay.

"The Paterson stone is similar to Ravensfield stone; colour, grey and light brown, the latter preferred, it also requires care in selecting; used upwards of twenty years ago in the balustrades and other ornamental works at the Court-house, Paterson, and within the last few years in other public buildings at that place.

"Of Muswellbrook stone, some very durable specimens can be seen in the Court-house, Post and Telegraph Office, and Commercial Bank at that place; also in upper part of base course at Court-house, Scone. That obtained from the Grass-tree Quarry, and spotted with bran-like marks throughout, I have always found very durable.

"Some of the Greta stone is very durable, but requires great care in selecting; good specimens are to be seen in the Court-house and Lock-up at Branxton, near Greta.

"The Rutherford stone is similar to Ravensfield, but of lighter colour, and requires care in selecting."

Resting in the undulations of the surface of the Sydney (Hawkesbury) Sandstone is a lacustrine deposit of fine clays and shales, known as the Wianamatta Series; from these are manufactured bricks, tiles, terra-cotta, and pottery, of the best quality, for the supply of Sydney and its suburbs. Samples of the latter with the raw clay and shale were shown by the following:—Clyde Pottery (G. M'Arthur); Petersham Brick Works (Elphinstone & Wilson); Ashford Brick Works (Tabrett & Draper); Beulah Brick Works (Bakewell Bros.); Eureka Pottery (W. J. Carter); The Warren Brick Works (E. Curlewis);

Frogmore Brick Works (Despointes Bros.); Newtown Steam Brick Works (Goodsell Bros.); J. T. Gibson, Gore's Hill, North Willoughby; G. Cochrane, Mowbray Park, North Willoughby; R. Cook, Marrickville; J. Paul, Waterloo; F. Wheeler, Riverstone; Cumberland Pottery (F. Liebentritt); Harber & Co., St. Peters.

From a shaking bog near Tumut, Mr. Travers Jones, M.P., exhibited a fine china clay, the following analysis and comparison made by Mr. J. C. H. Mingaye, F.C.S., between it and clays of known worth will be of interest:—

	Chinese.	St. Zrieux.	Cornish.	New South Wales.
Silica	50·5	48·37	46·32	44·46
Alumina	33·7	34·95	39·74	37·85
Oxide of Iron	1·8	1·26	0·27	A minute trace.
Lime	......	......	0·36	0·22
Magnesia	0·8	Trace.	0·44	Trace.
Potash	1·9	2·40		1·18
Soda			12·67	
Water	11·2	12·62		16·29

XVI.—Coal.

The approximate area of the Carboniferous strata in New South Wales is estimated at 23,950 square miles. The principal coal-beds exist along the coast to the north and south of Sydney, and on the Great Northern, Great Western, and Great Southern Railway Lines. The mines first opened are situated in the immediate vicinity of Newcastle; and it is from there that the Colony obtains its largest supply. In many districts the coal crops out on the face of the hills; and can be cheaply got by driving tunnels. The coal-shipping facilities at Newcastle are by staiths and steam and hydraulic cranes. Full descriptions of the various coal-seams worked in New South Wales have been given by Mr. John Mackenzie, F.G.S., Government Examiner of Coal-fields, in the Annual Reports of the Department of Mines, and in the *Mineral Products, &c., of New South Wales*, 2nd edition, 1887. Writing of the Upper Coal Measures in the Western District the Government Geologist says:—" They are 480 feet thick, resting comformably on the marine beds of the lower coal-measures, and overlaid by more than 500 feet of Hawkesbury sandstone. The seam worked, which is 10 feet thick, is the lowest in the series, and lies about 25 feet above the marine beds, and is the same seam worked by the Bowenfels, Eskbank, Lithgow Valley, Zig Zag, and Vale of Clwydd Collieries. This seam of coal crops out on the surface of the railway line near Bowenfels. It dips at a low angle of 3 to 5 degrees to the north-east, and is therefore easily worked; and as it passes under the vast extent of mountain ranges to the north and east it will be inexhaustible for generations to come." The No. 1, or uppermost seam, is worked at the Katoomba and Hartley Vale Collieries, and has been opened out near Mount Victoria, Mount Wilson, and between the Zig Zag and Mount Clarence. The production of coal has increased very rapidly of late years. In 1833, 328 tons were raised, and in 1887, 2,922,497 tons. Several seams of petroleum coal have been found, and the coal from two of them is retorted for the manufacture of "kerosene oil." Their thickness varies from a few inches up to 5 feet. The Hartley shale yields 130 gallons of crude oil, or 18,000 cubic feet of gas per ton, with an illuminating power equal to forty candles. The total production of coal to 31st December, 1887, was 39,892,862 tons, of the value of £19,698,831, and of petroleum coal, 481,252 tons, of the value of £1,083,174. Sections and samples of the coal-seams worked in the Northern, Western, and Southern Coal-fields were exhibited.

NEWCASTLE HARBOUR, AND ITS FACILITIES FOR SHIPMENT.*

"Newcastle, in the county of Northumberland, the trade of which is second only to that of Sydney, owes its great commercial importance to the different coal-mines which have been opened out close to and within 32 miles of the harbour.

"On the south or town side of the harbour there is a continuous line of wharf 3,600 feet long belonging to Government, 1,470 feet of which is occupied by four steam cranes for the shipment of coal, 660 feet for cargo berths for deep draught vessels, 500 feet reserved for the Sydney passenger steamers (owing to the increased size of the new boats put on the Sydney passenger service this wharf has lately been considerably increased in length and width), 400 feet is used as a general cargo wharf, including a lumber berth for loading vessels with timber, and 570 feet for shipment of coal with four shoots. The whole length of the wharf is lit up with gas.

"At Bullock Island, on the western side of the harbour, a substantial timber Government wharf, 6,293 feet in length, has been constructed along the face of what was formerly known as the ballast dyke; 4,493 feet of this wharf is set apart chiefly for the shipment of coal. The loading is performed by hydraulic cranes, of which there are eight erected and four in course of construction—six being 15-ton cranes, capable of shipping 1,000 tons of coal each in twelve hours, and two 25-ton cranes, which can be used for discharging heavy machinery, &c., when necessary. Ships of the largest class can load under the hydraulic cranes, and proceed to sea through deep-water channels recently dredged. There are also three 50-foot ballast jetties 200 feet apart. It is proposed to spend immediately a sum of £50,000 to further increase the shipping facilities at Bullock Island. Some 2,000 feet of wharf will be erected as a commencement of a 90-acre basin inside the present wharf, which (basin) it is intended to dredge to a depth of twenty-five feet, where vessels will be able to lie in slack water; and the whole will be lit up with the electric light. The remainder of this wharf is used by vessels discharging ballast, copper and other ores, or general cargo. A branch double line of railway connects the wharf with the Great Northern Railway, and along the back of the wharf is laid a very extensive system of sidings and standage room for working the coal traffic. Each crane has a full and empty line of railway, and lifts the coal waggons of six to ten tons, and slewing them round, discharges the coal into the hold of the ship.

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* Descriptions of the seams of coal worked in New South Wales; by John Mackenzie, F.G.S., Examiner of Coal Fields. *Mineral Products of New South Wales, 1887, 2nd Edition*, p. 98.

"At Stockton, on the northern side of the harbour, a Government wharf, 600 feet long, with two 15-ton steam cranes, capable of shipping 1,000 tons of coal each in twelve hours, is completed.

"In addition to these Government cranes, the Australian Agricultural Company have three large private shoots, at which 1,200 tons of coal can be loaded in 12 hours. Vessels loading from them can discharge their ballast on to the company's ballast wharf, lying safely alongside at a draft of eighteen feet six inches and upwards. They load vessels under their shoots to a draft of nineteen feet six inches; and the Waratah Coal Company have two shoots at Port Waratah capable of shipping 600 to 700 tons in twelve hours.

"The estimated present capabilities for shipment of coal at the above-mentioned places in Newcastle Harbour are about 16,000 tons in 12 hours, which, when the additional six hydraulic cranes at Bullock Island, and the two at Stockton, are erected, will be increased to 24,000 tons.

"The quantity of coal shipped in 1886 to foreign and intercolonial ports was 1,544,694 tons, valued at £828,189; and the largest quantity of coal taken by a sailing vessel was 3,320 tons, and by steamer, 3,203 tons.

"There are forty collieries at work and opening out in the Newcastle District, which raised 2,178,116 tons of coal, valued at £1,084,555.

ILLAWARRA DISTRICT AND ITS FACILITIES FOR SHIPMENT OF COAL.

"The Wollongong Harbour and Basin is situated forty-five miles south of Sydney Harbour, and at low tide there is a depth of thirteen feet of water at its entrance and alongside the wharf, where there are three cranes capable of shipping 1,800 tons of coal per hour. The Belmore Basin has a depth of seventeen feet of water at its eastern side, where there are four shoots each capable of shipping 100 tons per hour; but as only two vessels can load there at the same time the largest quantity of coal shipped by them is 200 tons per hour, or 2,000 tons per day. The largest steamships which have coaled at the harbour are the 'Barrabool' and 'Wentworth,' drawing 15½ feet of water, and carrying 900 tons, and the largest sailing vessel took away 700 tons.

"In addition to the Government appliances for shipment of coal at Wollongong the Coalcliff, Bulli, North Illawarra, and Mount Kembla companies have jetties of their own, from which coal is sent by steam colliers to Port Jackson and elsewhere.

"The Coalcliff jetty has a depth of eighteen feet of water at high tide, and fourteen feet at low tide, and can ship 100 tons per hour. They have two steam colliers carrying 250 tons each; and the greatest quantity of coal shipped per day has been 520 tons.

"The Bulli jetty has a depth of twenty-six feet of water at the shoots, which are capable of discharging 120 tons of coal per hour each, into steam colliers, of which they have three. The largest carries 700 tons, and the others 500 and 300 respectively.

"The North Illawarra Coal Company have just completed a fine jetty, 870 feet in length, which has twenty-six feet of water at their shoot at high tide; and they can ship about 120 tons per hour.

"The Mount Kembla jetty has a depth of twenty-six feet of water at their shoot at low tide, and the company can ship about 120 tons per hour therefrom, and have sent away 1,472 tons in a day. The largest ship that has loaded from it is the 'Titus,' with 1,000 tons of coal, and drawing seventeen and a half feet of water.

"The coal raised in the Illawarra and Southern districts, in 1880, was 240,211 tons, and in 1886, 370,830 tons, or an increase of 130,629 tons in the last six years.

THE WESTERN COLLIERIES AND THEIR RAILWAY AND SHIPPING APPLIANCES.

"All the Western collieries are adjacent to, or within a short distance of, the Great Western Railway, and they have for many years had the supplying of coal to the Government railway locomotives, &c. Their coal meets with a ready sale for manufacturing, household, and other purposes in all the suburban and inland towns, and large quantities of slack are sold for brick and tile making.

"Appliances will shortly be completed, and ready for use, for the shipment of coal at Darling Harbour, Sydney, at its junction with the Great Western Railway.

"The Western collieries have almost doubled their output in the last six years, the quantity raised by them in 1880 being 146,960 tons, and 281,229 tons in 1886.

TABULAR STATEMENT of Composition of New South Wales Coals.

COALS OF NEW SOUTH WALES MINED FOR EXPORT.	Water.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Analyist.
Northern District. *								
1. Ferndale Colliery, Newcastle; ash, buff-coloured	2·10	36·22	57·24	3·84	0·60	1·296	61·08	Dixon.
2. Newcastle Wallsend Colliery, near Newcastle; ash, reddish	2·29	34·21	58·60	4·28	0·62	1·347	62·88	,,
3. ,, ,, ,, ,, ,, ,, pinkish	2·75	34·17	57·22	4·64	1·22	1·333	61·86	Liversidge.
4. Australian Agricultural Co.'s Colliery; ash, white and heavy	2·22	32·60	57·52	5·35	1·33	1·297	62·87	,,
5. ,, ,, ,, ,, ,, reddish	1·65	35·45	57·84	4·44	0·62	1·286	63·28	Dixon.
6. Co-operative Colliery, Plattsburg; ash, reddish	2·45	34·38	58·24	4·20	0·73	1·310	62·44	,,
7. Waratah Colliery, near Newcastle; ash, buff-coloured	2·45	38·16	54·12	4·64	0·63	1·293	58·76	,,
8. ,, ,, ,, ,, reddish	2·21	36·70	55·82	4·15	1·12	1·303	59·97	Liversidge.
9. Newcastle Coal-mining Co.'s Glebe Colliery; ash, buff-coloured	2·14	33·36	59·16	4·76	0·58	1·283	63·92	Dixon.
10. New Lambton Colliery, near Newcastle; ash, reddish	2·61	30·62	59·56	6·72	0·49	1·291	66·28	,,
11. Minmi Colliery, Hexham; ash, reddish	2·59	33·87	56·49	5·61	1·44	1·280	62·10	,,
12. Redhead Coal Company; ash, grey	2·09	33·48	57·04	6·84	0·55	1·325	63·88	,,
13. Anvil Creek Colliery; ash, white	1·74	41·10	47·90	7·80	1·46	1·323	55·70	Liversidge.
14. Greta Colliery; ash, buff-coloured	2·25	39·21	54·41	2·72	1·41	1·287	57·13	,,
Southern District.†								
1. Mount Keira Colliery; ash, white	1·15	23·51	64·65	9·70	0·99	1·379	75·35	Liversidge.
2. Mount Kembla Colliery; did not coke; ash, white	1·50	19·74	67·18	10·72	0·86	1·363	None	,,
3. Illawarra Coal Company's Colliery; ash, grey	0·70	22·04	68·08	8·76	0·42	1·354	76·84	Dixon.
4. Coal Cliff Colliery; coke not very perfect; ash, greyish	0·86	18·22	69·84	10·80	0·28	1·378	80·64	,,
5. Osborne Wallsend Colliery, Wollongong; ash, grey	1·19	21·07	66·92	10·20	0·62	1·404	77·12	,,
6. Bulli Colliery; ash, grey	0·65	21·65	65·86	11·28	0·74	1·361	76·96	,,
7. Coal Cliff Colliery	1·61	19·68	68·08	10·28	0·35	1·372	78·36	,,
Western District.‡ *Coals mined chiefly for local use.*								
1. Lithgow Valley Coal Co.'s Colliery; coke hard; fairly lustrous; ash white.	1·95	34·18	52·34	10·12	1·41	1·329	62·46	Liversidge.
2. Lithgow Valley Coal Company's Colliery; ash, grey	2·24	28·48	58·80	9·68	0·80	1·340	None	Dixon.
3. Eskbank Colliery. Coal, rather dull; ash, greyish-white	2·70	28·78	57·88	9·88	0·76	1·329	None	,,
4. ,, ,, ,, ,, ,, coke, tender; ash, white	2·00	33·55	49·97	12·91	1·57	1·355	63·18	Liversidge.
5. Vale of Clwydd Colliery. Coal, rather dull; ash, grey	2·15	35·02	52·36	9·72	0·75	1·328	None	Dixon.
6. ,, ,, ,, Coke, compact, fairly lustrous; ash, greyish-white	2·10	33·35	53·38	9·80	1·37	1·323	63·18	Liversidge.
7. Bowenfells Colliery. Ash, white and dense	2·36	28·35	56·54	11·40	1·35	1·399	None	,,
8. Katoomba. Coal, fairly bright and hard; coke, soft and dull; ash greyish-white.	2·90	25·82	61·34	9·26	0·68	1·326	70·60	Dixon.
9. Katoomba. Coal, very dull-coloured; no true coke; ash, greyish-white	2·25	26·28	60·84	10·04	0·57	1·400	None	,,

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*The coals of this district are all very similar in appearance, being firm, and show a bright laminated structure, with traces of mineral charcoal; they are all highly bituminous, cake strongly in the fire, and yield bright, hard, sonorous cokes.

† The coals of this district are characterized by a somewhat dull colour, but are firm and strong. They may be classed as free-burning bituminous, as although they do not cake in the fire they are readily coked in an oven.

‡ These coals are properly non-coking bituminous; although they all coke when fresh from the pit, they lose this property by exposure; they are compact, and vary in appearance from fairly bright to dull-coloured

TABULAR STATEMENT of Composition of New South Wales Coals—*continued.*

	Water.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Analyst.
COALS OF NEW SOUTH WALES NOT WORKED, OR WORKED FOR LOCAL CONSUMPTION ONLY.								
1. Northern District, Russell's. Coal streaky, irregular, bright and dull; coke, firm, bright, lustrous; ash, pink.	1·85	44·09	49·95	2·70	1·41	1·274	53·65	Liversidge.
2. Teralba. Coal, bright, stained with oxide of iron; coke, fairly bright; ash, reddish.	4·65	32·84	52·68	8·16	1·67	1·350	60·84	Dixon.
3. Teralba. Coal, bright; coke, dense, bright, and lustrous; ash, grey	3·81	30·22	54·44	8·52	3·01	1·290	62·96	„
4. Lake Macquarie Coal, fairly bright; coke, hard and dense, moderately bright; ash, white.	3·65	31·93	54·66	8·82	0·94	1·34	63·48	„
5. Dymock's Jamberoo. Coal, firm and compact, non-coking; ash, grey	1·50	20·22	56·56	20·70	1·02	1·455	None	Liversidge.
6. Berrima. Coal, somewhat tender; coke, bright, lustrous, much swollen; ash, white.	1·70	32·78	53·84	10·40	1·28	1·364	64·24	„
7. Berrima. Coal, somewhat tender; coke, soft and dull-coloured, much swollen; ash, greyish.	1·90	21·17	57·67	18·25	1·01	1·37	75·92	Dixon.
8. Berrima. Coal, rather dull-coloured; much swollen, fairly lustrous and hard; ash, white.	1·21	19·95	41·30	36·56	0·98	1·56	77·86	„
9. Berrima. Coal, rather dull-coloured; coke, little swollen, dull and friable; ash, white.	1·26	15·61	48·34	33·92	0·87	1·51	82·26	„
10. Berrima. Coal from Wingecarribee River; coal, hard and bright with reddish incrustation; coke, hard, fairly lustrous; ash, white.	1·41	30·20	53·15	13·46	1·78	1·355	66·61	„
11. Berrima. J. J. O. Atkinson; coke, swollen and fairly bright; ash, greyish white.	1·26	26·61	62·28	9·40	0·45	1·408	71·68	„
*Western District.**								
12. Rylstone, near Mudgee, Stewart, Taylor, & Co. Coal, dull, with bright fracture; coke, strong, fairly bright; ash, greyish white and bulky.	7·70	36·42	51·48	9·76	0·64	1·300	61·24	Dixon.
13. Northern District, Rix Creek, Singleton. Coal, bright, but rather tender, slightly caking.	2·8	37·00	54·0	5·6	0·51	...	59·6	Latta.

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* These coals are properly non-coking bituminous; although they all coke when fresh from the pit, they lose this property by exposure; they are compact, and vary in appearance from fairly bright to dull-coloured.

From a report by W. A. Dixon, F.C.S., F.I.C., published in "Mineral Products of New South Wales;" by Harrie Wood, Under Secretary for Mines, 1887.

"A Block of Coal was exhibited from the Borehole coal-seam, worked by the Australian Agricultural Company from under their 2,720 acres of freehold and leasehold land, at a depth of 200 feet at their Hamilton pit, about 2 miles by their railway from Newcastle Harbour. It averages 10 feet 6 inches in thickness, it is very free from faults, lies very regular, dips about 1 in 40 south-east, and has an average specific gravity of 1·28. This Company's appliances for haulage, drainage, and ventilation of the mine, comprise all the latest improvements; and their's is the only colliery that has a Guibal Fan in place of an underground furnace for ventilation purposes. 387,074 tons of round and small coal valued at £184,750, were raised in 1886; and 803 men and boys were employed underground, and 172 aboveground daily, when the colliery was at work; and the total quantity of air produced in the mine by the Guibal Fan is from 90,000 to 112,000 cubic feet per minute. They have appliances for an output of 1,600 tons of round and small coal per day of eight and a half hours. *

"A full section was exhibited of the Coal-seam worked by the Burwood Coal-mining Company at Little Redhead, about five miles by the Company's Railway from the Newcastle Harbour. This colliery was only commenced to be opened out by the present company in September, 1883, on 1,000 acres and upwards of leasehold land, the property of E. C. Merewether, Esq. On December 10, 1884, a winding shaft 14 feet 6 inches in diameter was commenced to be sunk to the Borehole coal-seam by Mr. Simpson, which was passed through at a depth of 266 feet on 10th May following. Their pithead and all other arrangements in connection therewith contains all latest improvements, such as detaching hooks to their cage fixings, steel slips, waggons, &c.; and have present appliances equal to an output of 800 tons of round and small coal per day of eight and a half hours. The coal-seams dip about 1 in 40 to the south; and the Borehole coal is similar in quality to that worked at the Newcastle Coal Company's Colliery adjacent thereto. 72,566 tons of round and small coal, valued at £39,911, were raised in 1886; and 225 men and boys were employed underground, and 47 aboveground daily when the pit was working.

"The Borehole coal-seam worked at the before-mentioned Newcastle collieries represents one and the same seam. It is a bright bituminous caking coal of first-class quality for steam, household, coking, and smelting purposes, a good gas coal, and there has as yet been found no coal equal to it in New South Wales for all these general purposes. The No. 2 or Burwood seam, worked at the South Waratah, New Lambton, and Burwood Collieries has, so far, proved to be the next best in quality in the Newcastle District, and a considerable quantity of it was sold from these collieries in 1885.

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* Compiled from "Descriptions of the Seams of Coal worked in New South Wales," by John Mackenzie, F.G.S., Examiner of Coal-fields.—*Mineral Products of New South Wales, 1887, 2nd Edition.*

"A section of coal was exhibited from the Borehole Coal-seam, worked by Messrs. Brown, at Brown's Duckenfield Collieries, six miles by rail from the mine to shoots erected alongside the Hunter River, where vessels of large size are brought from Newcastle Harbour to be loaded with coal, a distance of about twelve miles. The property consists of over 3,000 acres, and the coal is wrought out from adits driven into the hill side. Its specific gravity is about 1·28, and the coal-seam dips slightly to the south-west. They ship coal also at Newcastle Harbour, and raised 227,798 tons of coal, valued at £110,237, in 1886, and employed 501 men and boys underground and 105 aboveground daily when the colliery was at work. They have four furnaces in their two collieries about one mile apart, producing in their mine from 85,000 to 90,000 cubic feet of air per minute.

"A block of coal was shown from the Greta Colliery, near Newcastle, being a section of the coal-seam sunk to, and now being worked by the Greta Coal Company, on 2,136 acres of leasehold land at the Greta Colliery B pit, at a depth of 450 feet from the surface. The coal lies very regular, is very free from faults, and dips about 1 in 6 to the west. The shaft is fifteen feet in diameter, and is fitted up with all necessary appliances for lifting and despatching large quantities of coal per diem. When sinking the pit a great number of Carboniferous fossils, such as *Spirifera*, *Producta*, *Conularia* and *Orthoceras* were found; and a *small patch* of rich petroleum oil cannel coal, or boghead mineral, has been found and worked out from under the property. Inflammable gas, in small quantities, occurs in this coal. 98,282 tons of round and small coal, valued at £49,141, were raised in 1886; and 254 men and boys were employed underground, and 49 aboveground daily, when the colliery was at work.

"A section of Coal was exhibited from the Borehole coal-seam, where sunk through by the Hetton Coal Company, at Bullock Island, adjacent to the wharf, the steamer cranes fronting the Newcastle Harbour. It was cut at a depth of 237 feet from the surface, by a shaft 15 feet 10 inches in diameter, lined with cast-iron tubing for a depth of 180 feet from the surface. The sinking commenced 27 November, 1885, and was completed 19 March, 1887. The coal-seam had a total thickness (including bands) of 22 ft. 6 inches. It is of excellent quality, suitable for house-fire, steam, gas, blacksmith, and coking purposes. A compound winding engine with two 26-inch cylinders and a 54-inch stroke, three boilers 6 feet in diameter and 34 feet long. Tangye pumps with an air compresser to work them instead of steam, a substantial head-gear, and three screens, &c., have been erected, and the company anticipate raising large quantities of coal during 1888.

"A small block of coal was exhibited from the New Lambton Colliery C pit, Newcastle—opened out in 1884 by Messrs. Dibbs and Brown, on 640 acres of their 1,225 acres of New Lambton Colliery freehold land, situated near Adamstown, and about 5 miles by their railway from the Newcastle Harbour. The Borehole coal is wrought out on the long-wall system at a depth of 243 feet from the surface, and the Burwood seam is worked from an adit. They raised from their New Lambton, New Duckenfield, and New Lambton Coal-pit collieries 71,370 tons of coal, valued at £33,454, in 1886, and employed 206 men and boys underground, and 83 aboveground daily, when the colliery was at work.

"A block was exhibited from the Borehole coal-seam, opened out on the Newcastle Wallsend Coal Company's 9,000 acres of freehold land at Dark Creek, near Wallsend, situated about 6½ miles from the Newcastle Harbour.—Eight feet in thickness is wrought out for a distance of over 1 mile south of their Dark Creek adits, at which place it commences to get thinner, and deteriorate, as it extends further south in the property. It is very free from faults, lies very regular, and dips about 1 in 60 south-west and south. The coal is brought to the surface through adits, near the entrance of which there are three stationary engines that draw it in miners' skips of 12 cwt. each, up slight inclines, on to the landing-stage erected alongside the company's railway, where they have appliances for despatching 2,200 tons of round and small coal per day of eight and a half hours. 483,884 tons of round and small coal, valued at £240,000 11s., were raised in 1886; and 940 men and boys were employed underground, and 180 aboveground. They have three furnaces producing in their mine from 200,000 to 205,090 cubic feet of air per minute.

"A block of coal was shown from the Borehole coal-seam, worked by the Newcastle Coal-mining Company, on 1,400 acres of land leased from E. C. Merewether, Esq., at the Glebe, 2½ miles from the Newcastle Harbour by rail, and found at a depth of 303 feet from the surface.—This colliery was opened out and the coal won by the late J. Winship, Esq., who for fifteen years was colliery viewer for the Australian Agricultural Company, and resigned his appointment with them to invest in and open out this colliery. Their haulage, drainage, and ventilation arrangements are all that could be desired. The coal lies very regular, is very free from faults, and dips about 1 in 40 south. 183,573 tons of round and small coal, valued at £83,181, were raised in 1886; and 400 men and boys were employed underground, and 93 aboveground. They have present appliances for an out-put of 850 tons per day of 8½ hours, and when the pit-top, &c., arrangements are shortly completed at their new pit, it will be largely supplemented.

"A small block of coal was exhibited from the Waratah Colliery at South Waratah. A township near the mine, called Charlestown, has sprung up since the opening out of these coal-seams. The Burwood coal-seams, seven feet six inches in thickness, about five feet of which is wrought, is the one they are now working at the Charles' pit, at a depth of 250 feet from the surface. The pit is 10 feet in diameter, and the head-gear engines, pumping apparatus, &c., are all of the best construction. It dips about 1 foot in 40 to the south, is worked on the long-wall system, and is very free from faults. 7,753 tons of round and small coal, valued at £3,774, were raised in 1885; and 40 men and boys were employed underground, and 38 aboveground, daily, when the colliery was at work. No coal was wrought from this seam in 1886.

"A full section of coal was exhibited, showing thickness of the coal-seam worked at the West Wallsend Colliery, near Newcastle.—The Borehole seam has, with bands, a workable thickness of 5 feet 4⅞ inches, on the West Wallsend Coal Company's property. The winding shaft is fifteen feet in diameter, and 492 feet in depth; the furnace shaft is ten feet in diameter, and 492 feet in depth. The colliery is situated in the Parish of Teralba, County of Northumberland, and will be fourteen miles by rail from the Newcastle Harbour when their branch line of about five miles in length has been constructed to the Government railway, near the Teralba station. Two coupled 25-inch cylinder winding engines, a conical drum ten feet to twelve feet in diameter, four boilers five feet six inches by thirty-three feet, and an iron head-gear, &c., have been erected, and when the railway line, now in course of construction, is completed, it is intended to ship coal to Newcastle. The coal is suitable for house-fire, steam, gas, blacksmith, and coking purposes.

"A block of coal and a number of remarkable concretions of coal were exhibited from the Stockton Colliery, Newcastle.—In March, 1885, the Stockton Coal Company, with great success, under the able management of Mr. Rossiter, civil engineer sank through the Borehole coal-seam 29 feet 7 inches in thickness, at a depth of 335 feet 6 inches, on their leasehold land at Stockton, adjacent to the Stockton wharf, the Hunter River, and harbour of Newcastle. Iron cylinders, fifteen feet in diameter, made of cast-iron 1⅛ inch in thickness, and formed of rings five feet six inches in depth, weighing about eight tons, were sunk by pressure by Mr. Rossiter, to hard rock, to a depth of eighty-four feet, and from there to the bottom of the shaft he sunk through a 4-feet 6-inch coal-seam, and the yard coal-seam two feet only in thickness, with conglomerates, hard grey post (rock) and shales between them and the Borehole coal-seam. The machinery, &c., erected, consists of two 60-horse power coupled horizontal winding engines, a 45-horse power condensing engine, driving an eight-inch pump, two shell boilers forty feet long and six feet six inches in diameter, poppet-head, pit-head, &c. Screens, tramway, and wharf are now completed, and the Company are in a position to raise large quantities of coal. The coal-seam is of excellent quality, is intersected with dykes near the pit bottom, and varies in thickness. In one portion of the mine they work the upper part of the seam of coal, above the six feet six inches of shale, and in another the lower or nine to ten feet of coal. It has a south-easterly dip; and 84,495 tons of round and small coal, valued at £40,121, were raised in 1866; and 182 men and boys were employed underground, and 40 aboveground daily, when the colliery was at work.

" Coal core was exhibited by the Young Wallsend Coal-mining Company from their property near Newcastle.

" Coal was exhibited from the coal-seam sunk through by the Singleton Colliery Company, near Rix's Creek and Singleton. The company have constructed a tramway over a mile in length to connect the mine with the Great Northern Railway. Six feet nine inches in thickness is the portion worked; it is a bituminous coal, suitable for steam, household, gas, smelting, blacksmith, and coking purposes. The dip is about 1 in 12 to the north-west. They raised 8,920 tons of round and small coal, valued at £4,695, in 1886.

" Coal was also exhibited from the Rosedale Colliery, Camberwell, Great Northern Railway, 55½ miles north of Newcastle.

" A block of coal was exhibited showing thickness of seam at the New Anvil Creek Colliery.—Being a section of the coal-seam worked at Anvil Creek, adjacent to the Greta Colliery and the Great Northern Railway. It is thirty-two miles by rail from the Newcastle Harbour, and dips about one in nine westerly. It is identical with the seam worked at Greta.

" Coal and shale were exhibited from Prior's property, parish of Black Jack, county Pottinger, near Doughboy Hollow.—This coal-seam is six feet ten inches thick, of excellent quality could be cheaply wrought from adits, and a tramway could be easily constructed to the North-western Railway line, a distance of about seven miles.

" A block of coal was exhibited from the Bulli Colliery.—From a seam seven to eight feet in thickness of clean coal, free of bands, an average specific gravity of 1·36, and dipping about 1 in 30 to the north-west, on the Bulli Company's 2,628 acres of freehold and leasehold land, situated at Bulli, about eight miles north of Wollongong harbour. The coal-seam outcrops at a height of 350 feet above sea-level, in the Illawarra ranges, fronting the Pacific Ocean, where adits are driven into it. It is situated one mile from the Illawarra railway, now constructed, and an incline and locomotive tramway, two miles long, conveys the coal from the mine to the Bulli Company's jetty, where steam colliers come alongside and take away the coal. They raised, in 1886, 99,923 tons of round and small coal, valued at £22,457, and employed 276 men and boys underground, and 95 aboveground daily when the colliery was at work.

" A full section was exhibited of the coal-seam worked at the South Bulli Colliery This company's property is situated between, and immediately adjoins, the properties of the Mount Kembla Coal-mining Company and the Mount Keira (Osborne—Wallsend) Colliery, and contains 7,000 acres. This section included the floor of fire-clay, and the roof, both being cut out with the coal. The coal-seam is from seven to eight feet in thickness, and is entirely free from bands. The coal-seam is 700 feet above sea-level, and has about 600 feet of cover. It is equal in quality to any steam coal in the Southern Coal Field. Mr. Wm. Wiley, Post Office Chambers, Pitt-street, Sydney, is the chairman of the directorate, and Mr. W. H. Vivian, of Norwich Chambers, Hunter-street, the secretary.

"A large block of coal, about 2 tons, was exhibited from the Mount Kembla Colliery, four miles south of Wollongong, being a section of the coal-seam opened out by Mr. Burall, on the Mount Kembla Coal and Oil Company's property, consisting of 2,100 acres of freehold and leasehold land at Mount Kembla, near Wollongong. It is the upper or No. 1 coal-seam, four feet to four feet six inches in thickness of clean coal, free from bands, identical with that worked at the Osborne-Wallsend, and other collieries in the Illawarra district; and is wrought from an adit at a height of about 750 feet above sea-level. A tramway, five miles in length, has been constructed from the mine to Five Island Point, where a jetty has been constructed, and steam colliers, &c., come alongside and take away the coal. The Illawarra railway, now in course of construction, crosses their tramway at about four miles from the adit, and fifty miles from Sydney. 51,794 tons of round and small coal, valued at £31,076, were raised in 1886, and 150 men and boys were employed daily underground, and 40 aboveground.

"A large block of coal was exhibited from the Mount Pleasant Colliery, Wollongong, on 800 acres of freehold and leasehold land, situated at Mount Pleasant, near Wollongong. The seam averages about seven feet six inches of clean coal free of bands, has an average specific gravity of 1·36 and dips west and north-west about 1 in 30. It is the uppermost coal-seam in the Illawarra district, and outcrops about 600 feet above sea-level in the high ranges fronting the Wollongong harbour, where adits, situated two miles from the Illawarra railway, now being constructed, pierce it, and an incline and locomotive tramway of about three miles in length conveys the coal from thence to the Wollongong harbour. They raised 71,913 tons of round and small coal, valued at £28,355, in 1866, and employed 134 men and boys underground, and 59 aboveground daily, when the colliery was at work.

"A section was exhibited of the coal-seam worked at the Osborne-Wallsend Colliery on freehold land belonging to the Osbornes, at Mount Keira, near Wollongong. It averages about seven feet six inches in thickness of clean coal, free of bands, has an average specific gravity of 1·36, and dips west and north-west about 1 in 30. It is the uppermost coal-seam in the Illawarra district and is found outcropping at a height of about 600 feet above sea-level in the high ranges fronting the Wollongong harbour, where adits, situated two miles from the Illawarra railway, now being constructed, are driven into it, and an incline and locomotive tramway of about three miles in length conveys the coal from the mine to the Wollongong harbour. 77,386 tons of round and small coal, valued at £28,897, were raised at this colliery in 1886, and 170 men and boys were employed underground, and 55 aboveground daily, when the colliery was at work.

"Coal was exhibited from the Katoomba Coal and Shale Company's Mine, from the No. 1 coal-seam, opened out in 1878 by Mr. North on an extensive area of land at Katoomba, in the parish of Jamieson. Adits have been driven into the coal in a gorge, about 800 feet below the Great Western Government Railway, from which the coal is brought by an incline and endless tramway, two miles in length, to the railway, where it is put into Government trucks, at a distance of sixty-six miles from the metropolis and harbour of Port Jackson. The coal is very free from faults, and has a slight easterly dip. 25,00 tons of round and small coal, valued at £6,250, were raised in 1886; and 55 men and boys were employed underground and 21 aboveground daily when the colliery was at work.

"A block of coal was exhibited showing thickness of the portion of seam worked at the Zig-Zag Colliery; being a section of the Great Western Zig-Zag Company's Lithgow Valley coal-seam, opened out in 1883, and now worked on 410 acres of leasehold and by Messrs. Wilson and Saywell, about one mile from the Vale of Clwydd Colliery, and ninety-six miles by rail from Sydney. The coal is similar in quality, dips in the same direction, and is as free from faults as that worked at the other Lithgow Valley collieries before mentioned. Powerful winding and pumping engines and a substantial pit-top have been erected, and they raised 60,000 tons of round and small coal, valued at £15,000, in 1886; and employed 65 men and boys underground, and 10 aboveground, daily, when the colliery was at work.

"A block of coal was also exhibited from the Lithgow Valley Colliery.—situated about ninety-six miles by rail from the harbour of Port Jackson. This property consists of 1,752 acres, and the coal has been proved on all sides by adjoining workings. The seam is 10 feet 6 inches in thickness, about five feet six inches of which is worked through an adit in a mountain on the western boundary, about 400 yards from the Great Western Railway, with which it is connected by a private siding. The coal lies very regular, is very free from faults, and has a wavy dip of about 1 in 20 east and north-east.

Coal was also shown from the Pulpit Hill and Medlow Colliery.

From the Mittagong Coal-mining Company's Colliery, at Joadja Creek, near Mittagong, a full section of the seam worked was exhibited.

A magnificent display was made of petroleum oil cannel coal, "kerosene shale," and its products, from the Australian Kerosene and Mineral Company's mine and works at Joadja Creek, near Mittagong.

The following is an analysis of the "Shale."

Volatile hydrocarbons	82·50
Fixed carbon	11·00
Ash	6·50
Specific gravity, 1·238.	100·00

"The petroleum oil cannel coal (Boghead mineral) is worked by the above company at Joadja Creek, near Berrima, in the county of Camden, from which place a tramway eight miles in length conveys the mineral to the Great Southern Railway, a distance of seventy-seven miles from Sydney and the harbour of Port Jackson. The dip is about 3½° north 20° west. A heading has been driven in near the centre of the deposit, and shoots erected for sending down the cannel from the mouth of the heading to a tramway constructed in the valley below. The petroleum oil cannel coal is of excellent quality, lies very flat, is easily and cheaply wrought, and sections of the seam have been laid bare in several places. This Company raised and used in the manufacture of oil and its products, and sold for gas purposes in the colonies, America, and Great Britain, 25,700 tons, valued at £64,250 in 1886, and employed ninety men and boys underground and twenty above ground, daily, when the mine was at work. The richest of the mineral gives 15,399 cubic feet of 48-candle gas per ton, and has a specific gravity of 1·098. When made into oil and its products, it yields over 150 gallons of crude oil to the ton. The products obtained from the company's 'shale,' consisted of kerosene oil, soaps (various kinds), candles (various kinds), lubricating oils, lubricating greases, stearine, paraffin, sulphuric acid, wood preserving oil, brick oils, liquid fuel.

"A full section was exhibited from the petroleum oil cannel coal-seam worked by the New South Wales Shale and Oil Company at Hartley, near Mount Victoria, in the county of Cook. An incline and tramway about one mile in length takes it to the Great Western Railway, at a distance of eighty-one miles from Sydney and the Port Jackson harbour. It dips to the east. This is the mine where oil and its products were first manufactured from the New South Wales boghead mineral in 1865, our late Attorney-General—Mr. J. Want—being then the manager of the mine and oil works erected adjacent thereto, which works were afterwards removed to Waterloo, Sydney, where the manufacture of oils, paraffin, and other products are still carried on successfully. They raised and used in the manufacture of oil and its products, and sold for gas purposes in the colonies, America, and Great Britain, 17,863 tons, valued at £35,726, in 1886; and employed 100 men and boys underground and above ground daily, when the mine was at work. The richest of the mineral yields over 130 gallons of crude oil per ton when used for oil and its products, and over 18,000 cubic feet of 40-candle gas when gas only is extracted from it. Its specific gravity is 1·052.

Petroleum oil cannel coal was exhibited from Ruined Castle, Katoomba, yielding in 100 parts—

Sp. Gr. 1·046.

Hygroscopic moisture	·35
Volatile hydrocarbons	81·02
Fixed carbon	10·10
Ash	5·00
Sulphur	·53
	100·00

From Bathgate, Marangaroo, one hundred and one miles by rail from Sydney, yielding about 17,000 cubic feet of gas per ton, with an illuminating power of over thirty-six candles, or ninety gallons of crude oil per ton.

And also from Sugarloaf, Mount Victoria, seventy-seven miles by rail from Sydney, yielding over 17,000 cubic feet of gas per ton, with an illuminating power of about thirty-eight candles, or ninety to one hundred gallons of crude oil per ton.

Graphite was exhibited from Undercliff Station, near Wilson's Downfall, New England, but was of poor quality.

IX.—Note on two specimens of *Lepidodendron* from the Lower Carboniferous (?) of Goonoo Goonoo; by ROBERT KIDSTON, F.G.S., of Stirling, N.B.

[Plate V.]

IN both specimens, all traces of the original plant have entirely disappeard, and we have only their impressions on a very soft ochre-coloured matrix, which shows well the present form of the leaf-scars. Both the fossils have been much distorted by pressure, active in a direction almost parallel to their growing axis; or, in other words, to speak of the leaf-scars individually, active on their upper margins. That the leaf-scars do not now possess their original form, is at once evident from their irregular and contorted outlines.

As proof of the correctness of this conclusion, if we examine the smaller and more sharply defined specimen (Pl. V, fig. 1) which is only about 2½ inches long, and an inch wide, it is seen that the leaf-scars at its uper part, are more compressed than those towards its base; and in the other specimen, of which two leaf-scars slightly enlarged, are shown in Fig. 2*a*–*b*, they are even less compressed than those at the lower part of Fig. 1.

The general appearance of the specimens, though difficult to express in words, will be admitted by all, who have had any practical experience of fossils, to be the result of pressure acting in the direction already indicated.

Concluding that the fossils do not now show the original form of the leaf-scars, the next question demanding consideration is whether any known species of *Lepidodendron*, if subjected to similar conditions, would be likely to assume the form of the Goonoo Goonoo examples. When dealing with *Lepidodendra*, in almost all cases, unless we have well preserved leaf-scars, their specific determination is very unsatisfactory. The present fossils have fortunately certain characters of so well marked a type, that though perhaps not enabling us to determine the species with positive certainty they agree so closely with *Lepidodendron Volkmannianum*, Sternb., that their identity with this plant appears to me very probable. Two leaf-scars of *L. Volkmannianum* are shown (Pl. V, Fig. 3), for the purpose of comparison with the Australian specimens. It will be seen in comparing these figures that the leaf-scar of *L. Volkmannianum* has a flat basal boundary line (Pl. V, Fig. 3*b*), with a rounded upper margin (Pl. V, Fig. 3*a*). Now, if we compare Figs. 2*a* and 2*b*., scars from the larger Australian example, with the sketch of *L Volkmannianum*, it will be seen that the form of the parts, bearing the corresponding letters, agree pretty well, allowance being made for the pressure to which the specimens have been subjected. Of all *Lepidodendra*, *L. Volkmannianum* is perhaps the only one which has characters so peculiar to itself, that would allow of any comparison with distorted specimens, such as those under consideration, and the little evidence the present fossils afford, points to their identity with that species.

In Mr. C. S. Wilkinson's letter, accompanying the fossils, which were collected by Mr. D. A. Porter, of Tamworth, he gives as their horizon "Lower Carboniferous or Upper Devonian (?)" *L. Volkmannianum* is, I believe, as far as at present known, restricted to the Culm of the Germans, and its equivalent in Great Britain, the Calciferous Sandstone Series of Scotland. From an isolated species, and that not being quite free from doubt, as to its specific identity, we are not in a position to corelate horizons, but taking into consideration all the circumstances of the case, I am more inclined to regard the beds from which it was collected as Lower Carboniferous than Upper Devonian.

It is very desirable that additional and better preserved specimens be secured, from which these notes might be confirmed or rejected.

The following references to the literature of *Lepidodendron Volkmannianum*, Sternb., may be of assistance to those who may wish to examine the matter for themselves :—

Lepidodendron Volkmannianum,	Sternberg, Vers., I. fasc. 4, p. X, pl. LIII, f. 3.
,,	Schimper, Traité Pal. Vég., vol. II, p. 23.
,,	Stur, Culm Flora, Heft. II, p. 393, pl. XVIII, f. 4, and pl. XXIII, 2–4 (5 ?).
,,	Renault, Cours. Bot. Foss., 1882, Ann. II, p. 17, pl. I., f. 8.
Sagenaria Volkmannianum,	Sternberg, Vers. II, p. 179, pl. LXVIII, f. 8.
,,	Römer, Palaeontographica, vol. III, p. 46, pl. VII, f. 15.
,,	Rhode, Beiträge zur Pflanzen Vorw., 1820, p. 82, pl. VII, f. 4 and 5.

X.—On the Post-Tertiary Ossiferous Clays, near Myall Creek, Bingera; by WILLIAM ANDERSON, Geological Surveyor.

[Plates VI—X.]

I.—Introduction.

DURING the past fifty years numerous discoveries of the fossil bones of extinct Post-Tertiary vertebrates have been made from time to time in various parts of this Colony, and in other parts of Australia. Among the earliest notices of their occurrence in New South Wales are papers by the following authors:—W. Pentland (1830)[*], Professor Jamieson (1831)[†], and Major Sir T. L. Mitchell (1831)[‡]. Since that time the literature dealing with the description of the various gigantic animals whose bones have been periodically unearthed, and the deposits in which they lay, presents quite a formidable list of papers, the majority of which are from the pen of Prof. Sir Richard Owen.

The deposits in which Post-Tertiary fossil bones have been found in Australia may be classed in two groups—the Pleistocene and Recent alluvia, clays and river drifts; and the Post-Tertiary ossiferous breccias of our limestone caves. The former group comprises a variety of deposits. Isolated bones and small collections of bones have been frequently met with in the soils and subsoils, where these have been laid bare in section by superficial denudation, chiefly on the great interior plains of this Colony and Queensland, but also over the Colony generally. They likewise occur in clays which represent old dried up boggy springs or lagoons, such as the "Cuddie Springs" on Mara Creek, near Brewarrina, and in distinctly stratified deposits sometimes of considerable extent, which have evidently been laid down by running water, such as the Myall Creek deposit near Bingera; while in some instances, as at Young and Gulgong, they occur in Pleistocene river drifts.

The more important deposits, however, are those of the second group, comprising the ossiferous breccias in our limestone caves, such as the Wellington and Fish River Caves, &c. The majority of the bones occurring in these breccias have no doubt been introduced into the caves by the action of streams, the evidences of which, in the presence of well rounded pebbles, are well marked in almost every case. In this Colony the limestone beds in which our principal caves have been worn, many of them containing bone breccias, are coralline, generally of a dirty bluish grey colour, and belong to the Siluro-Devonian series. Although in the breccias the fossil bones are in a better state of preservation than they are in the Pleistocene clays, &c., the latter ossiferous deposits are still of great importance, and will amply repay systematic exploration.

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[*] Communication verbale sur les Ossements trouvés dans une Brèche calcaire sur la Rivière de Hunter (N. S. Wales). *Bull. Soc. Géol. de France, 1830, I, p. 144.*

[†] On the fossil bones found in the Bone Caves and Bone Breccias of New Holland.—*Edinburgh New Phil. Journ., 1831, X, p. 393.*

[‡] An account of the Limestone Caves of Wellington Valley, N. S. Wales.—*Proc. Geol. Soc., 1831, I, No. 21, p. 331; and Edinburgh New Phil. Journ., 1831, XXV., p. 179.*

The fossil vertebrate remains thus preserved to us are of the most interesting character, revealing, as they do, the gigantic marsupial fauna which must have existed on this continent during a comparatively recent period, and exhibiting an analogous feature in animal development to that which has been found to have obtained in other continents, where, during Pleistocene times, there existed in each great endemic area, a fauna consisting of giant representatives of that of the present time in the same area. It is still an open question, from the few systematic explorations of our bone deposits that have been made, whether representatives of any of the species of our larger Pleistocene vertebrates were in existence after the appearance of man on this continent. In New Zealand we have conclusive proof that a gigantic representative of its Pleistocene fauna in the Moa (*Dinornis*), existed down to the human period, and, for a considerable time after the advent of man, co-existed with him. In this relation, there are other deposits besides those which have been laid down by natural agencies, to which careful attention ought to be given, namely, the more or less artificial accumulations left by man, analogous to the "kitchen-middens" and other deposits of Northern Europe, which contain human remains and relics, and the bones of the animals on which he subsisted. Doubtless, there are numbers of such accumulations in various parts of the Colony, but particularly along the sea coast, in positions which were habitually frequented by the various tribes, or smaller communities, either as camping grounds or rock-shelters during certain periods of the year, or as places set apart for the performance of certain rites and ceremonies. At the present time we have far greater facilities for obtaining a knowledge of the position of such localities than will be the case with future investigators, because we have still among us numerous persons who during the early days of the Colony were personally acquainted not only with the manners and customs of the native blacks, but also with the exact localities which were most favoured by the latter as positions for camping, or for the performance of their various ceremonies. It is probable that many of these places were frequented by generation after generation of the same community. If such were the case, we may expect to find, on investigation, not only human weapons, and probably human remains, in such localities, but also the bones of the animals which co-existed with man, and whose flesh he used for food. It will thus be seen that if, by such investigations, we are to prove or disprove the co-existence of representatives of these gigantic Pleistocene vertebrates with man, our explorations must also be carried on among those deposits in which his remains are likely to be found; so that investigations in Post-Tertiary palæontology and pre-historic archæology must be carried on simultaneously.

II.—Localities.

The chief localities from which Post-Tertiary vertebrate remains have been obtained in New South Wales, are the following :—

Post-Tertiary alluvia, clays, &c.—Cuddie Springs, near Brewarrina; Myall Creek, near Bingera; Liverpool Plains; Tamworth; Paroo River; Barrier Ranges; Hunter River; Pye's Creek, near Vegetable Creek; Armidale; Gulgong; Young; &c., &c.

Caves (bone breccias).—Wellington; Fish River; Wombeyan; Murrumbidgee (Cave Flat); Goodridigbee; Cowra, or Belubula; Isis River; Molong; Boree.

There are numerous other known caves, which have, however, never yet been explored for fossil bones, but in which they would doubtless be found if systematically investigated. Among these the following may be mentioned:—Yarrangobilly, Kempsey, Abercrombie, Wollombi, Cargo, &c.

Besides the remains of the larger extinct Pleistocene vertebrates, there are to be found in almost all our caves, chiefly in the accumulated dust which covers the floors of the smaller side chambers, the bones of recent existing marsupials, such as wombats (*Phascolomys*), wallabies (*Halmaturus*), bats, rats, and mice, &c.

At the Canadian Gold-lead, near Home Rule, about half-way between Mudgee and Gulgong, the auriferous Tertiary river drift was found to occupy a large irregular cavity in limestone, which in Tertiary times must have been a cave opening into the valley in which the river drift was being deposited. In the wash-dirt in this cave a number of fossil bones were discovered, but they are, however, the remains of truly Tertiary animals.

III.—Myall Creek Deposit.—Position.

The bone deposit which has just been worked out, is situated at Bone Camp Gully, on Portion 121, Parish of Durham, County of Murchison (Pl. VIII). Sections of the series of beds among which it occurs, were exposed by being cut through by a small creek, running northwards into Ironbark Creek, which is an affluent of Myall Creek, a tributary of the Gwydir River. The deposit is about six miles south-east from Mr. M'Donald's station, on Myall Creek, which is sixteen miles to the east of Bingera, on the Bingera and Inverell road.

IV.—Geology of District.

In this district the country presents an irregularly undulating appearance. In geological structure in consists chiefly of Tertiary basalt, with here and there an occasional outcrop of the underlying Palæozoic rocks, of limited extent, in some places exposed by the denudation of the basalt which had covered them, and in others the slate hills still stand high above the level of the basalt, as they no doubt did during the time when the Tertiary lavas overflowed and flooded so large an area of the north-eastern part of this Colony. Superficially most of the country, especially the flats, along the courses of the creeks, and the low-lying grounds, is covered by a considerable thickness of black soil, which when moist is a tenacious and unctuous clay, and has been chiefly derived from the decomposision of the Tertiary basalt. In numerous positions where the basalt has been either pierced in well-sinking, or worn through by surface denudation, the characteristic Tertiary valley deposits are found to be present under large areas. These consist of variously-coloured pipeclays, with beds of more or less carbonaceous clays and gravels. Of Pleistocene and recent deposits there are the series of clay beds among which the bones occur, the black soil alluvia, which have a very general distribution, and the pebbly drifts and sands of the present water-courses. In the immediate vicinity of Bone Camp Gully, the principal geological feature is the prevalence of Tertiary basalt, with the Pleistocene clays, which cover the greater part of the 40-acre block, No. 121, besides portions of the neighbouring blocks. A short distance to the south of the gully there is an old river course, represented by a considerable thickness of pebbly drift. About ten chains up, on the western side of the gully, is a small cliff, formed of a series of slightly calcareous grits, sandstones, and shales, which dip at a low angle towards the south. Here the ossiferous clays are seen to rest unconformably on the upturned edges of these rocks, which may probably form a small outlier of the coal-bearing Carboniferous strata which cover such a large tract of country some distance to the west. About six chains up the gully from the junction of the two creeks a spring rises in the bed of the creek from below the lowest clay bed. The flow of water from it is periodical, and seldom lasts for any length of time. Sometimes the creek bed below it is completely dry one evening, and next morning the water is seen flowing along it quite freely. The spring occurs opposite that portion of the western bank of the creek at which the bone bed outcrops.

V.—Description of Sections.

The sections of the various Pleistocene clays exposed in Bone Camp Gully differ from each other on the two sides of the gully. The eastern side is formed entirely of light grey and white clays, covered with surface soil, these grading gradually into each other without showing any distinct line of demarcation. No bones were found in the clays on this side of the creek. On the western side the whole series of beds is exposed. Their total thickness probably does not exceed thirty-five feet, the bone bed occurring about midway in the series. This section (Pl. X.) consists of the following beds, as seen in the face laid bare during the excavations:—(1) Greyish black soil and subsoil passing downwards into—(2) a greenish grey clay. which, at a depth of six feet nine inches from the surface, rests upon—(3) a bed of black carbonaceous clay, four feet nine inches in thickness, which becomes gradually a light chocolate colour towards its upper and lower surfaces. Immediately below this is—(4) the bone bed proper, which varies in thickness from one to three feet, and is a stiff, tenacious, greenish-grey clay, which passes downwards for a considerable depth, carrying isolated bones, and containing less clay, with more sand and pebbles towards it lower surface. This bed, with its upper ossiferous portion, must be at least eight feet thick. Some three chains up the gully it is seen to rest on the decomposed upper surface of the Tertiary basalt, while higher up it rests on—(5) a bed of ferruginous pebbly grit, on which the present creek is now depositing its flood sands. The beds have all a slight dip towards the north-west. The black carbonaceous clay bed thins out before reaching the eastern side of the gully, and the bone bed proper is not present on that side of the creek. The outcrop of the bone bed with the overlying carbonaceous clay extends in a north and south direction along the western side of the gully for a distance of about five chains, and they both thin out in those directions. The upper surfaces of the various beds, where distinctly seen in section, present a wavy outline.

VI.—Description of the Bone Bed proper.

A few isolated bones occurred for some distance down in the lower clay bed, and also scattered through the black carbonaceous clay, but the chief deposit was in the upper part of the former. Vertically the portion carrying the bones varied in thickness from one to three feet, while horizontally, along the outcrop of the beds, it extended north and south for a distance of one and a quarter chains. It was proved, by the excavation made, to extend from the outcrop, in a westerly direction, for about one and a quarter chains, and at that distance the bones had not altogether disappeared. Laterally along the outcrop isolated bones occurred outside the area, where they were most abundant. The lower portion of the bed is a somewhat loose sand, containing pebbles, but towards the top, where the chief collection of bones occurred, it was principally clay, with fine grains of quartz and occasional pebbles. The pebbles occurring in the clay along with the bones were not very numerous, except in a few spots, and consisted of the following rocks:—altered Silurian slates, jasperoid rock, quartzite, quartz, Tertiary basalt and tachylite, calcareous grits and shales. The first four varieties were the most common. All the pebbles were of small size, well-rounded, and water-worn, the largest not exceeding three inches in diameter. The least rounded and largest fragments were the pebbles of calcareous grit and shale, which were identical with the series of inclined calcareous rocks which are exposed close by in the bed of the creek, and on which the clay beds rest uncomformably. The pebbles were less frequent in their occurrence from below upwards in the bed at the top of which the bones lay, and passing upwards they gradually disappeared, until, in the black carbonaceous clay overlying the bone bed, they occur but rarely. The clay in which the bones are embedded is stiff and tenacious when moist, but loses all its viscosity and falls into dust when exposed to the air, or heat of the sun. This enables the bones to be easily and thoroughly cleaned, because, when dry, the adherent clay can readily be picked or brushed off.

VII.—Mode of Occurrence of the Bones.

Although the bones had a wide distribution, both vertically and horizontally, throughout the clay beds, there was only one position in which they were obtained in any abundance, and in a fair state of preservation, namely, at the top of the lower greenish-grey clay. Here they lay in a jumbled mass, sometimes in small pockets, where they came in contact with each other; but generally they occurred singly, often a few inches, and sometimes a few feet apart. The long bones and larger flat bones were never found standing vertically in the clay, but were always in a horizontal position, or only slightly inclined when one end of a bone rested on its neighbour. The smallest depressions and foramina in the bones were filled with clay, which at the time of deposition must have been of the consistency of fine mud. Pebbles occurred not unfrequently in the clay with the bones, as if brought into position along with them. When first exposed the latter were so saturated with moisture that they readily went to pieces, unless handled very carefully; but many of them, when allowed to dry thoroughly, became quite hard and sound. As a rule, however, they were very soft and friable, and great difficulty was experienced in getting the larger bones out whole. In many cases large masses of the clay in which a bone was embedded had to be removed along with it, and the bone only separated from the clay after it had been dried and strengthened. The isolated bones occurring in the black carbonaceous clay were so much decomposed that they would not bear removal; in fact, the position of the majority of them was only marked by a ferruginous stain, the bony substance having entirely disappeared.

VIII.—Principal Bones occurring.

The excavation made in order to remove the bones, which had to be picked out individually, was of considerable extent. Several tons of bones were recovered, but the majority of them were more or less broken, although many perfect specimens were procured. Those which occurred most frequently in the deposit were the long bones of the limbs, the small bones of their distal extremities, and vertebræ, and, as a rule, these were also the most perfect, and in the best state of preservation. Rib bones were rather common, but were mostly broken into short fragments. Of the vertebræ, specimens of the axis and atlas were usually found entire, both in the case of those which had belonged to the smaller animals, such as the kangaroo (*Macropus*), &c., and also to the larger forms, such as *Diprotodon*, &c. Generally, however, only the bodies of the other vertebræ remained, the spines and the various processes having been broken off. Jaws, both large and small, occurred frequently, while isolated teeth were very abundant. The lower jaws of the larger forms were more frequently met with than the upper; indeed, the latter were rather rare. When they did occur, however, they never formed part of an entire cranium, but always consisted of the upper maxillary and palatal bones only, the rest of the cranium being absent. So far as I saw, there was no specimen that could be demonstrated to be a portion of the cranium proper of one of the larger animals, although there are undoubtedly small fragments of the cranial bones among the collection, which has, however, not yet been thoroughly examined. The bones of the pelvis were of rare occurrence, fragments of the thickest part of the os innominatum, about the rim of the acetabulum being the part generally met with. In one instance, however, a very large portion of the pelvis of one of the larger animals was found, consisting of the greater part of one os innominatum, and the sacrum. Nearly perfect specimens of large scapulæ were in a few cases obtained, while fragments of the scapulæ of smaller animals, generally consisting of the articular head of the bone, with a portion of the neck and the coracoid process, the blade being wanting, were of frequent occurrence. The remains of birds, although by no means common, were often met with.

Occurring in the ossiferous portions of the clays were numerous small fragments of bones, generally a few inches in length, and chiefly pieces of the longer limb bones, which had been broken into fragments prior to their deposition in the clays. In almost every case the sharp fractured edges and angles of these fragments had been slightly rounded by attrition, but they were by no means so well water-worn as the pebbles which occurred along with them. The fragments of the thicker bones rarely showed an entire transverse section of the bone, which had not only been fractured transversely, but also longitudinally. In the case of fragments of the thinner bones, the transverse section is generally complete, the bone not having been fractured longitudinally. The large majority of the broken fragments show unmistakably the teeth-marks of some carnivorous animal, or animals. Most of these marks are, however, too fine to have been produced by the carnassial teeth of *Thylacoleo*, although there are some of them which seem large enough and coarse enough to have been so produced. The fragments of bones which show evidences of having been gnawed, are chiefly pieces of the shafts of the longer limb-bones and ribs. The teeth-marks occur singly along the surface of the fragments, corresponding marks being often present on the opposite surface, indicating the action of the teeth of both jaws on the bones. Generally, however, the marks are confined to one or both ends of the fragments, which often bear evidences of having been bitten sharp off, while close to the sharply bitten end the surface is furrowed with teeth-marks, showing that whatever the animal was, by the action of whose teeth the marks were produced, it had a similar habit to that which the dog, and other carnivora possess, of holding one end of the bone on the ground, between the fore-paws, while it gnawed the opposite free end. Few of the teeth-marked fragments of bones belong to the skeletons of the larger animals whose remains occur in the deposit.

IX.—General Conclusions.

Age.—There can be little doubt as to the comparative age of this ossiferous deposit. From the presence of pebbles of Tertiary basalt and tachylite, and the fact that the whole series rests upon the Tertiary basalt of the district, its origin is certainly of Post-Tertiary date. The thickness of the series, the occurrence in the deposit of angular, as well as rounded water-worn pebbles, together with the relation which the whole series bears to the general level of the county, all point to the supposition that it more probably belongs to the Pleistocene than to the Recent period.

Origin.—The facts bearing on its probable origin, however, are hardly so clear and conclusive as those relative to its age. So far as observation went, no two or more bones, which might have been articulated together in the living animal, were found lying in such a relation to one another as to favour the supposition that they had been still united by ligaments or muscles at the time that they were deposited in these clays. This fact, taken in conjunction with many of those stated below, negative the idea that the animals whose bones occur here, died through getting bogged in this position, which at that time might be supposed to have been a boggy swamp. It does not seem likely that the periodically active spring coming from below the series of clays, had anything to do with their formation. It is, probably, merely an outlet for the drainage of the area covered by the series of clay beds. From the distinctly stratified character of the deposit, and the facts that the long bones and flat bones, almost without exception, were found to lie with their longer axis horizontally, that most of the broken fragments of bones had their fractured edges and angles slightly water-worn, and that all the weaker and more easily destroyed portions of the bones were absent, it may safely be concluded that the deposits were formed and the bones brought into position by the agency of running water. The current could not have been very rapid, for the pebbles are never large, and judging from the uniformity of texture of the various beds, its velocity must have remained very uniform during the whole period of deposition, although the occurrence of the pebbles less frequently from the lower beds upwards in the series, shows that during the deposition of the upper beds its power must have become somewhat diminished. The presence of pebbles of calcareous grit, &c., similar to the rocks that are seen *in situ*, farther up the gully, would indicate that the direction from which the current came was from the southward, the present drainage of the district being also from that direction. The transportation of the bones must have extended over a considerable period of time, during the deposition of the successive beds. They were first carried in singly, while the lower clays were being laid down, their number gradually increasing until a maximum was reached in the bone bed proper, and thereafter only isolated specimens were deposited along with the overlying carbonaceous clay. The two latter beds seem to form merely a local patch in the whole series of clays, occupying a circumscribed area and intercalated as a lenticular mass among them, the upper and lower grey beds of which, in the section in Bone Camp Gully, are very similar in character and occur outside the area of the carbonaceous clay as a single bed of considerable thickness. During the deposition of these ossiferous clays, the general physical features of the surrounding country must have been very much what they are at the present time, except for the effects of superficial denudation in lowering the high grounds, and tending to produce a general levelling of the country. The fact that many of the bones show distinct evidences of having been gnawed would, I think, indicate that they had lain exposed on the surface of the ground for a considerable time before they were washed into the present deposit where they were immediately covered up. That they have been transported as individual bones from some neighbouring locality into the deposit in which they were found, seems to me beyond a doubt, and it is probable that the transporting agent is to be found in the stream which laid down the gravels, and of whose former presence we have evidence in the immediate neighbourhood to the south, the direction from which the transporting current probably came.

We frequently see at the present time, on many of our rivers, the formation of stratified sand and clay deposits of considerable extent, and quite similar to those under consideration, although, no doubt, they are being formed more slowly than was the case in Pleistocene times. Such deposits are generally formed at intervals along the courses of rivers where the enclosing high grounds widen out and leave more or less open flats, whose general level in the neighbourhood of the river's banks is nearly the same as that of the river itself, and the outlet from which is somewhat confined. These flats, during every periodical rise in the waters of the river or creek, become flooded, and on them are accumulated the sandy clays and finer sediments, which are carried over a wider area, where the currents are slower, than the heavier material (gravel, boulders, &c.) which is deposited in the immediate neighbourhood of the channel proper, where the current is much more rapid, and consequently its transporting power much greater. It seems to me probable that, under conditions such as these, the bones were transported from some neighbouring locality in which they had been accumulated, and were redeposited in their present position. It is clear that they could not have been transported any great distance, but, under what conditions they occurred in the position in which they were originally accumulated we have at present, no evidence to show. Whether they were washed from a prior deposit, or cleaned out from a cave or rock-hollow, or whether they had been primarily deposited in a boggy swamp which in course of time may have been washed away by the river, so far, there are no facts to prove; but there is not the slightest doubt that the position from which they were exhumed, was not the original one in which the skeletons of the various animals, whose remains occur in the deposit, were disarticulated into their separate bones.

The question may present itself as to whether or not such Pleistocene ossiferous deposits were of glacial origin, that is to say, were they deposited as a result of the presence of glacial conditions of climate in the more elevated parts of the Colony, with a consequent lowering of temperature generally? And was such a lowering of temperature one of the causes of the extinction of these large Pleistocene vertebrates? Taking the deposits themselves, there is nothing to indicate that the clays were a product of ice-erosion, nor do the pebbles show any traces of glacial action. As the remains of these animals have been found high up in the New England District, in the northern part of the Colony, that portion, which, under glacial conditions, would be the most intensely glaciated, their distribution in early Pleistocene times must have been very general. So little attention has yet been paid to glacial phenomena in this Colony, and so few facts relating thereto collected, that from the present state of our knowledge a Post-Tertiary Glacial Epoch cannot be demonstrated to have been an indisputed fact. There are, however, unmistakable evidences in South Australia, and probably Victoria, that a cold period intervened between the middle Tertiary and the present time. If such glacial conditions obtained in this Colony during later Pleistocene times, there can be little doubt that they were among the most potent causes of the extinction of these large Pleistocene vertebrates, just as has been proved to have been the case in other parts of the world where the large Pleistocene forms of life died off on the advent of glacial conditions of climate. But neither the deposits themselves nor the surrounding country show evidences of glacial action, so that the facts obtained from a study of these Pleistocene bone deposits in this relation do not warrant, nor even tend towards the conclusion that the extinction of these animals was due to the approach of a period of diminished temperature immediately anterior to the present time.

Among that portion of the collection which I had the opportunity of cursorily examining in camp, there were no evidence of man, either in the presence of his implements or weapons, nor in the occurrence of his remains. It is of the greatest importance that we should have the evidence for or against the contemporaneity of man with those Pleistocene animals, based upon observations made during the excavation of such deposits as the present, but so little systematic work of this kind has yet been done that the facts recorded relating to this interesting question are of the most fragmentary and unsatisfactory kind. By working out both sets of deposits, on the one hand by the excavation of the Pleistocene ossiferous deposits, and on the other by the exploration of the recent accumulations left by man, we should be certain to discover a point which would give us the earliest evidences of his presence, but as yet we cannot say whether that point was before or subsequent to the total extinction of the gigantic Pleistocene fauna, and it can only be conclusively proved by the laborious, careful, and systematic exploration of all our Post-Tertiary accumulations both natural and semi-artificial.

The palæontological significance of such collections of Pleistocene bones as this cannot fail to be of the utmost importance and scientific interest, as helping to elucidate the questions relating to the evolution of the almost unique indigenous vertebrate fauna of the present time in this island-continent.

I must acknowledge here the great interest taken and the ready assistance given by Mr. McDonald, of Myall Creek Station.

The collection was made after much trouble and labour by the Survey Collector, Mr. C. Cullen.

XI.—On Further Evidence of a Large Extinct Struthious Bird (*Dromornis*, Owen), from the Post-Tertiary Deposits of Queensland; by R. ETHERIDGE, Junr., Palæontologist.

[Plates XI—XIII.]

I.—Introduction.

A SMALL collection of bones, found at an old spring in sinking a well, at a depth of twenty feet from the surface at Thorbindah, near Cainwarra Station, on the Paroo River, were recently forwarded to the Government Geologist, by Mr. A. S. Cotter, of that place. In addition to bone fragments of kangaroos and *Diprotodon* and teeth of the latter, three specimens especially attracted notice as the remains of birds. A closer inspection showed them to be the right tibia and left fibula of a large Struthious Bird, and the right tibia of an Emu (*Dromaius*).

II.—History of Struthious Birds.

Before describing these in detail, it may not be without interest to refer to the history of Struthious Birds in Australia. The first intimation of the former existence of this interesting group on this continent seems to have occurred to Professor Sir Richard Owen amongst the gatherings of the late Sir Thomas Mitchell, Surveyor-General of New South Wales, from the Wellington Caves. In the Palæontological Appendix to Mitchell's "Three Expeditions into the Interior of Eastern Australia,"[*] Professor Owen figured[†] a femur, which he referred to in subsequent writings[‡] as that of a "large struthious bird." From 1838 until 1869 nothing appears to have transpired relating to extinct birds in Australia, but in that year the late Rev. W. B. Clarke wrote to the Editor of the *Sydney Morning Herald* (letter dated May 19th), announcing the discovery of a *Dinornis* femur from under thirty feet of alluvial clay covering 150 feet of drift, in a well on the Peak Downs, between Lord's Table Mountain and the head of Theresa Creek. The day previous to this, however (May 18th, 1869), the late Mr. Gerard Krefft, then Curator of the Australian Museum, wrote to the same paper, stating that the specimen in question was the "shank bone" of a bird "allied to the flightless moas." This opinion was reiterated in the year but one after,[§] when he compared this interesting relic to the similar bone of the extinct *Dinornis robustus*, Owen, of New Zealand.

Mr. Clarke's letter was republished in the *Geological Magazine*[‖] in 1869, but a curious discrepancy exists between these two documents. As communicated to the *Herald*, the letter states that the femur was found under the alluvial clay, "covering 150 feet of drift, and rested on what is said to have been a granite rock." In his letter to the *Geological Magazine*, on the other hand, Mr. Clarke says that the alluviul matter "rested on 150 feet of drift, pebbles, and boulders, on one of which (at that depth) rested a short thick femur." From these contradictory statements the position of the bone in question must remain a doubtful point. A plaster reproduction was sent by the Rev. Mr. Clarke to Sir Richard Owen at the same time, the original remaining in the Australian Museum. On receipt of the cast, this eminent osteologist was able to demonstrate the relation of the bone to the corresponding one, not in the Moa (*Dinornis*), but in the existing Emu, and named in *Dromornis australis*.[¶] The full description was published later,[**] and from this excellent memoir the following quotation may be taken:—"I infer that in its essential characters this femur resembles more that bone in the emu than in the moa, and that the characters in which it more resembles *Dinornis* are concomitant with, and related to, the more general strength and robustness of the bone—from which we may infer that the species manifested dinornithic strength and proportion of the hind limbs, combined with characters of closer affinity to the existing smaller, more slender-limbed, and swift, wingless bird peculiar to the Australian continent."

It should have been noted that, following Mr. Krefft's determination of this bone as that of a *Dinornis*, Mr. Clarke was led to indulge in some speculations on the former probable union of Australia and New Zealand. In consequence, however of Professor Owen's researches, such views were abandoned by the Father of Australian Geology.*

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[*] Two vols., 8vo. London, 1838.

[†] Pl. 3, figs. 12 and 13.

[‡] Trans. Zool. Soc., 1873, viii., Pt. 6, p. 381.

[§] Australian Vertebrata, recent and fossil, p. 37. (8vo., Sydney, 1871. Government Printer).

[‖] Geol. Mag., 1869, vi, p. 383.

[¶] Proc. Zool. Soc. 1872, p. 682.

[**] On *Dinornis* (Part XIX): Containing a description of a femur indicative of a new genus of wingless birds (*Dromornis Australis*, Owen), from a Post Tertiary deposit in Queensland.—*Trans. Zool. Soc.*, 1873, VIII., Part 6., p. 381, t. 62 and 63,

The next discovery of bird remains in Australia, or, perhaps, it should be said the preservation, is again due to the Rev. W. B. Clarke, who, in January, 1876, received from a Mr. Deitz the pelvis of a large bird, found at a depth of 200 feet at the Canadian Gold Lead, near Mudgee, County of Phillip,† From photographs of this fossil, Professor Owen wrote as follows:—" I make out the left acetabulum and surrounding parts of the pelvis of a bird about the size of *Dinornis ingens*, but differing in certain proportions of parts."

This pelvis is referred to in Sir Richard's twenty-first " Memoir on *Dinornis*,"‡ wherein, speaking of the above photographs, he remarks that the specimen "formed part of a bird's pelvis as large as that of the *Dinornis elephantopus*." In this essay there is also described "the left tibia of a flightless bird," and corresponding in size with the same part in *Dinornis elephantopus*. The bone in question is described in detail, and is believed to have been found in the Mount Gambier Range, South Australia. The interest attached to the fossil found by Mr. Cottor will be at once manifest, bearing in mind that it is a portion of the right tibia of such a bird.

This examination of the Mount Gambier fossil enabled Professor Owen to " establish the fact of a nearer resemblance in the tibia, as in the femur, of the gigantic wingless bird of Australia, to the genera still there represented (*Dromaius*, *Casuarius*), than to *Dinornis*, *Apteryx*, or *Struthio*."

Only two other references are necessary in this brief history of Australian struthious birds, namely to Sir Richard Owen's work on the " Extinct Wingless Birds of New Zealand,"§ in which his previous descriptions are recapitulated; and a more recent paper by Mr. C. W. de Vis, " The Moa (*Dinornis*) in Australia."‖ In this interesting communication the author describes a portion of the proximal end of the left femur of a struthious bird from the Darling Downs deposits. Although he produces several interesting facts in support of the dinornithic affinity of this bone, it opens up questions of such magnitude that further confirmatory evidence is desirable before the occurrence of *Dinornis* in Australia is accepted as a fact. Mr. de Vis has obligingly supplied the Mining and Geological Museum with a cast of this fragment, and I must confess that the resemblance between it and the corresponding bone in *Dinornis* is a strong one. To sum up then we find that four separate discoveries of bones of an extinct wingless bird have been made on the Australian continent, as follows:—

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* See Sedimentary Formations of N. S. Wales, 1875, 3rd edit., p. 5; 1878, 4th edit., p. 101.

† On *Dromornis Australis* (Owen), a new fossil bird of Australia.—*Journ. R. Soc. N. S. Wales for 1877, 1878.* XI, p. 41.

‡ On *Dinornis* (Part XXI): Containing a restoration of the skeleton of *Dinornis maximus*, Owen, with an Appendix, on Additional Evidence of the genus *Dromornis* in Australia.—*Trans. Zool. Soc.*, 1877, X., p. 186.

§ "Memoirs on the Extinct Wingless Birds of New Zealand, with an Appendix on those of England, Australia, New Foundland, Mauritius and Rodriguez" (2 vols., 4to London, 1879).

‖ Proc. R. Soc,, Queensland, 1884, I pt. 1, p. 23, t. 3 and 4.

Wellington Caves—A femur, by Sir. T. L. Mitchell.
Peak Downs—A femur (Rev. W. B. Clarke).
Canadian Lead—A pelvis, by Mr. Dietz.
Mount Gambier Range—A tibia (Professor Owen).
King's Creek—A femur (Mr. C. W. de Vis).

Now, the femora and the tibia, coming from what may be generally termed quaternary deposits, may, for arguments sake, be considered of the same geological age. But it is questionable if the pelvis from the Canadian Lead can be so regarded. As previously stated, it was found at a depth of two hundred feet in an auriferous lead of supposed Pliocene age, and it is therefore somewhat premature to class these remains as all of one period. Rather, would it not be better to consider the pelvis from the Canadian lead as one of the earliest bird remains yet extant on this continent, and of Pliocene age; and those from the other localities as representing a Post-Pliocene period. The following extract from a letter[*] of Professor Owen's to the Rev. Mr. Clarke will show that the Professor provisionally regarded the whole of these remains as one species—"The probabilities are that the femur from the breccia-cave of Wellington valley, that described from Peak Downs, your portion of a pelvis, and the South Australian tibia, are parts of the same genus, if not species. It is more conducive to progress to record them, until proof to the contrary be had, as parts of *Dromornis australis*."[†]

To consider the femur from the Canadian lead as Pliocene, will not in any way invalidate Professor Owen's assumption, for the bird may have lived on from Pliocene to Post-Pliocene times. On the other hand, it equally lends colour to the existence of two species, and this will probably turn out to be the case.

III.—Remains of Dromornis.

(*a*) ***Description of the Tibia.***—The bone forwarded from the Paroo River is the distal extremity of the right tibia of a bird, almost corresponding in size with the left figured by Sir R. Owen from the Mount Gambier Range, and referred to as ***Dromornis australis***. The articular surface is more or less worn and somewhat decayed, especially the condyles, otherwise the fragment is well preserved. It has been obliquely broken as near as possible about the centre of the shaft, some distance below the position of the medullarterial orifice, as there is no trace of the distal termination of the fibular ridge. (Pl. XI, Fig. 1; Pl. XII, Fig. 1; Pl. XIII, Fig. 1.)

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[*] Journ. R. Soc. N. S. Wales for 1877 [1878], xi, p. 43.

[†] Even this opinion was to some extent modified by Professor Owen only two years later. He said,—"One cannot, of course, state confidently that it," [i.e., the South Australian tibia] "is a bone of the same species of bird as the mutilated femur from the Cave of Wellington Valley, or of that from the drift at Peak Downs, in Queensland." *Mem. Extinct Wingless Birds, New Zealand, &c.*, 1878. *App.*, p. 6.

The bone has a dark blackish-brown appearance on the surface, a greyish hue at the fractured end, adheres strongly to the tongue, and effervesces slightly with acid. The anterior surface is deeply marked by the course of blood vessels.

The comparative measurements agree fairly well with those of Owen, bearing in mind the relative state of preservation of both bones. The dimensions of our fossil would appear to demonstrate that it was the tibia of a rather smaller individual than that referred to.

	Dromornis (Owen)		*Dromornis* (Paroo)	
	in.	lines.	in.	lines.
Transverse breadth of the shaft at the commencement of the distal expansion	2	2	2	1½
Transverse breadth of the shaft at the commencement of the distal condyles	3	5	3	0

The bone as preserved is eight and a quarter inches long, the broken proximal end of the shaft having a diameter of one and eleven-sixteenth inches, with a rounded oval section. The shaft is rather more compressed from before backwards than in the illustration of the Mount Gambier fossil, and does not expand very rapidly towards the condyles. A measurement taken across the precondylar groove, at that point which in *Dinornis* would be occupied by the "bridge of bone" gives two and six-sixteenth inches.

The inner condyle is the better preserved of the two, the outer being much decayed, and both exposing the porous structure of the bone. Judging the former, however, by its remaining portions, it would seem to be rather less in length, from before backwards, than the bone examined by Professor Owen.

The anterior surface of the shaft at its proximal end is flattened to some extent, but the posterior is more convex. The inner lateral surface is also flattened, or may be described as straight-walled, and is margined anteally by an extension of the distal extremity of the procnenial ridge, which is prominent, but obtuse.

There is an entire absence of roughening of the surface proceeding from muscular attachment, but on the contrary the surface of the bone is smooth fore and aft, and seamed with the meandering impressions of certain blood-vessels. On the anterior surface the most noticeable feature is the precondylar groove, which is traceable to within two inches of the broken proximal end of the shaft. At this point it is wide and shallow, gradually narrowing and increasing in depth, and at the same time curving towards the inner side. The shallow proximal end of this groove is quite contiguous to the inner lateral margin of the shaft, but as it progresses towards the fore part of the bone it takes up a median position, as described by Owen. The fossa, or deeper portion, between the commencement of the condyles, is more transversely obliquely placed and more open than in Professor Owen's figure of the left tibia. Its foramen is very much larger than the corresponding pit in the right tibia of *Dinornis crassus*; and at the same time, there is a most marked difference between the fore and aft thickness of this bone, immediately above the would-be position of the bony bridge, and that in the first cited species. In *D. crassus* it is one and two-sixteenth inches, but in *Dromornis* the measurement reaches one and six-sixteenth inches, *i.e.*, a difference of a quarter of an inch. The pulley-like articular surface appears to me both flatter and wider than in the Mount Gambier tibia, but when compared with the similar part in *Dinornis crassus*, very marked differences are perceptible. The inner and upper ends of the condylar ridges on the posterior side approximate closely in *Dromornis*, but they do not do so in *Dinornis crassus*, the result being that the intercondylar space or channel is much narrower throughout the whole of its course in *Dromornis* than in *Dinornis crassus*. At any rate, this is particularly noticeable at the upper or proximal posterior end of the channel in the former bird. The rounded edge of the precondylar groove at that point in the present bone, whence in *Dinornis* the piers of the bony bridge, or oblique bar, would spring, are much worn away, and would at first sight convey an impression that a similar structure had here existed. By following the general contour of the groove, however, and comparing with this, the mechanism in a *Dinornis* tibia, it is quite apparent that such a structure could not have existed in the present instance, and we are therefore dealing with a true *Dromornis* bone.

On the outer lateral surface, between the upper edges of the anterior and posterior condylar margins there is an almost median depression; this also exists in *Dinornis*. On the contrary, in the Emu and in the Cassowary, this does not exist, but the surface of the bone is plain and more or less flattened.

The bone substance is thick, measuring at the proximal fracture six-sixteenths of an inch, the central cavity being one inch in diameter, and somewhat less in a contrary direction. Sir R. Owen compared the Mount Gambier tibia to the similar bone in *Dinornis elephantopus*, but the correspondence in size with the distal end of that of *Dinornis gravis** is most marked.

It is not my purpose to regard the small differential details which exist between the present bone and the left tibia from the Mount Gambier Range, as specific. Many writers on palæontological osteology would doubtless do so, but I think all purposes will be served if we look upon the present fossil merely as an addition to the structure of *Dromornis australis*.

(*b*) *Description of the Fibula.*—Associated with the bone just described is another fragment, which, with the assistance of Mr. Henry Barnes, Articulator to the Australian Museum, I have come to the conclusion is the proximal end of the left fibula. (Pl. XI. f. 2, Pl. XII. f. 2., Pl. XIII. f. 2.) In its present state it is three and a quarter inches long. The upper articular surface is worn almost flat and broad, in fact, much broader than in the corresponding portion of the fibula in *Dinornis elephantopus*. The outer cap of the head is sharp, and the same side retires inwards, forming a strongly concave surface. The "fore and aft" measurement of the head is two and fourteen-sixteenth inches, the transverse or cross measurement being one and three-quarter inches. In *Dinornis elephantopus* the corresponding proportions are two inches nine lines, and one inch three lines respectively, whilst in a bone of this bird now before me, they are two and three-quarter inches and one and two-sixteenth inches.

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* Trans. Zool. Soc., 1873, viii, pt. 6, pl. 59.

The inner side in *Dinornis elephantopus*, between the two extremities of the head, is roughly triangularly concave. In the Emu it is elongately concave, but in the present fossil the similar surface is limited, to some extent protuberant, and deeply and closely marked by pits for muscular attachment.

The posterior prolongation of the head is very marked and long, projecting backwards as an obtuse elongated process, and when compared with the similar part of the fibula of *Dinornis elephantopus* is at once seen to be less thick and massive, but more projecting. In the Ostrich there is a further diminution, and a still greater in the Emu.

The diameter of the shaft in *Dinornis elephantopus* is one and fourteen sixteenths of an inch, at a corresponding point to that at which our bone is broken. The diameter of the latter is only one inch, proving it to be a less powerful bone at this particular point. The antero-posterior width of our fossil, at the fractured end, is one and thirteen sixteenths of an inch, that of the bird used for comparison nearly as possible the same.

The tibial articular surface is not shown through the fracture taking place at the proximal commencement of the articulation, whilst the posterior edge of the bone corresponding to this, but immediately under the head, is very sharp and prominent.

The first point which strikes one is the generally more massive outline of this fibula than that of *Dinornis*, such as the gigantic *Dinornis elephantopus*, especially in the wider and larger head. The next peculiarity is the outer concave and smooth surface under the head, which is markedly different to the structure of the bone both in *Dinornis elephantopus*, and the Emu. As both the tibia and fibula were found in company it is but reasonable to suppose that they are closely related one to the other.

IV. *Remains of Dromaius.*

(*a*) *History.*—The late Mr. Gerard Krefft recorded the Emu (*Dromaius*) as a Post-Tertiary fossil,* and bones of this bird are in the Australian Museum from the Wellington Caves and other localities. More recently, my former colleague,

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* Australian Vertebrata, recent and fossil, 1871, p. 37.

Mr. William Davies (late of the Geological Department, British Museum), described* the distal end of a mutilated tibia from the Wellington Caves, which is "interesting as being additional evidence of the still existing emu having been contemporaneous with the great extinct marsupials."

One of the most interesting points in connection with the occurrence of *Dromornis* at the Paroo River, is its association with *Dromaius*, thus lending colour to the belief of their co-existence.

(*b*) *Description of the Right Tibia.*—Amongst the Paroo fossils is the extreme distal end of the right tibia of an Emu, probably of a full-grown bird (Pl. XI., f. 4, Pl. XII., f. 3, Pl. XIII., f. 3). It presents certain peculiar modifications of structure, however, which are worthy of record. Chief amongst these is the great development of the extreme distal end of the shaft, as compared with the condylar portions. The following measurements will illustrate this:—

Name.	Measurement of the shaft at $1\frac{3}{4}$ inches above the condyles.	Measurement at the upper margins of the intercondylar surfaces.
Emu (living)............	Long .... $1\frac{3}{16}$ inch Short .... $\frac{11}{16}$,,	Long .... $1\frac{14}{16}$ inch Short .... $1\frac{6}{16}$,,
Emu (fossil)	Long .... $1\frac{7}{16}$,, Short .... $\frac{13}{16}$,,	Long .... $1\frac{10}{16}$,, Short .... $1\frac{4}{16}$,,

That is to say, in the fossil tibia the shaft is much the larger and more solid (Pl. XI., f. 4), but in the recent bone the condyles and portions near them are by far the more massive (Pl. XI., f. 3). In the fossil the cavity of the shaft is $\frac{14}{16}$ in. × $\frac{8}{16}$ in., but in the recent bone these measurements are reduced to $\frac{12}{16}$ inch and $\frac{7}{16}$ inch. In both the thickness of the bone is the same, viz., $\frac{2}{16}$ inch.

A consideration of these details led Dr. E. P. Ramsay and the Writer to regard this bone as distinct from that of the Emu of Eastern Australia. But whilst engaged in this investigation, a paper by Mr. C. W. De Vis was read before the Linnean Society of New South Wales, "A Glimpse of the Post-Tertiary Avifauna of Queensland."† Amongst the specimens was the distal end of a left tibia, with rather more of the shank preserved than in the specimen now before me. Through the kindness of Mr. J. J. Fletcher, M.A., I was allowed to examine and compare this bone with that in our collection, with the result that to me they seem identical. Mr. De Vis has named his tibia *Dromaius patricius*, and as I am in accord with him in regarding it as a new species, I have much pleasure in adopting the name applied by him.

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* Geol. Mag., 1884, i, p. 265.

† Proc. Linn. Soc., N.S. Wales, 1888, iii, pt. 8, p. 1277.

Mr. de Vis describes both the proximal and distal ends of the right tibia from separate examples, and the left coracoids. In regard to the distal part of the tibia, he notices the same peculiarities to which I have referred. The fossils are from King's Creek, "and with the exception of *Dinornis queenslandiæ*, nob., are the only bird bones which have reached the hands of the writer from that part of Darling Downs."

V.—Postscript.

A short abstract of this paper was published in the *Sydney Morning Herald*, of October 4th last; on the 5th instant, a letter appeared in the same newspaper from the Rev. J. E. Tenison Woods, stating that a discovery of the remains of an extinct Struthious Bird by him in 1866 took precedence of the determinations of the Rev. W. B. Clarke and Mr. Krefft, and complaining that his printed references to the same had been "ignored or passed over."

It is perfectly true that the rev. gentleman's references were overlooked, but not "ignored or passed over" in the sense his letter would imply, and the Writer is extremely sorry that the references mentioned were overlooked; it was, however a pure inadvertence.

It may not be out of place to examine briefly the statements contained in Mr. Woods' remarks on the bones believed by him to be those of the first recognized Struthious Bird in Australia. These will be taken in their order of publication, and commented on *seriatim*.

In the first notice* of these bones Mr. Tenison Woods says†:—"In sinking a well on the edge of a swamp, 14 miles north-north-west of Penola, some bones have been dug up, which were this day (April 25, 1866) recovered by me. They comprise two tibias and two tarso-metatarsal bones of some extinct and very large bird. The extraordinary length of the former bones, and the absence of any articular surface on the inner and posterior surface of the metatarsal bones show them to have belonged to some struthious bird very nearly allied to the emu. (*Dromaius ater*, Viellot ?); but as many osteologists are of opinion that specific distinctions cannot be determined by the skeletons of birds, this bird may have been something more than a mere species of emu. From the size of the bones it was evidently a larger, heavier, and more clumsy bird. The bones are both of right feet. The lateral surfaces of the three articular prolongations of the distal extremity are very concave; and at the extremity of the groove indicating the juxtaposition of the metatarsal pieces there is a large foramen extending from before backwards through the bone, perfectly enclosed on its inner side. In this respect the bone differs from our existing emu, in which the groove is quite open, prolonging the separation between the metatarsal pieces, and giving the external condyle a very long tapering appearance. In the fossil bone the condyles appear short, and stout, and very broad. I should propose the provisional name of *Dromaius Australis* for the bird until more bones are found. It is certainly quite extinct, but appears to have been contemporaneous with the natives, for these bones are marked with old scars, one of which must certainly have been inflicted by a sharper instrument than any in possession of the natives at present. There were, however, fragments of flint buried with the bones, and a native well is distant about 50 yards away."

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* Report on the Geology and Mineralogy of the South-eastern District of the Colony of South Australia, &c.; p.p. 33 (8vo., Adelaide, 1886. Government Printer), p. 7.

† Page 7.

In stating that the lateral surfaces of the three articular prolongations of the distal extremity are very concave, the author can only mean the free distal ends of the tarso-metatarsal bones. But the next sentence, "at the extremity of the groove indicating the juxtaposition of the metatarsal pieces there is a large foramen," is to the Writer unintelligible, unless the paragraph should read "grooves," of which there are of course two, the continuations of the interarticular spaces. The author then adds, "in this respect the bone differs from our existing emu, in which the groove is quite open." That is to say in the fossil bones a foramen exists, whereas in the emu it does not. I trust that my reading of the Rev. Mr. Woods' remarks is the correct one, because on the subject of the structure of the tarso-metatarsus of the Emu, as described by him, I cannot agree with him. In two skeletons before me the distal interarticular spaces between the metatarsals terminate in grooves, and the outer is interrupted in its course by a foramen, extending through the bone. How, then, can this constitute a difference between the fossil bone and the corresponding one of the Emu? As the only other difference pointed out, is that the condyles appear short, stout, and very broad, it becomes a question if the fossil bones might not have been those of an old individual of that species.

In his second series of remarks* the reverend author states:—"In 1865 the writer of this article found near a native well in South Australia the remains of another and much larger struthious bird, which had evidently been killed by the blacks in remote times. The provisional name of *Dromaius australis* was given to it, but since then its remains have been found in other places, and Professor Owen has named it *Dromornis australis*."

The third notice to be quoted reads:—"In 1866 I found the remains of a Struthious bird, much larger than the Emu, in one of the kitchen middens of the natives of South Australia. The bones were marked by the scrapings and cuttings of the flint knives of the blacks. I then stated that there was evidence that Australia had been formerly occupied by a wingless bird, much heavier and larger than the Emu, and I proposed for it the name of *Dromaius australis*. It has since been named *Dromornis australis* by Professor Owen, who has found that the bird had formerly a wide range in Australia."†

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* Natural History of New South Wales—An Essay (p.p. 60, 8vo., Sydney, 1882. Government Printer), p. 27.
† Proc. Linn. Soc. N. S. Wales, 1883, vii., p. 387.

In the first place there is a discrepancy in the date of discovery of these bones as given in the first and second extracts. In the former it is 1866, in the latter 1865. In the second place the first account says these remains were found in "sinking a well on the edge of a swamp," but in the third notice in "one of the kitchen middens of the natives of South Australia." Now this discrepancy has a very strong bearing on the relative importance of these bones from a geological point of view, coupled with the assertion that they bear the marks of the natives' weapons. If found at any depth in sinking a well the geological antiquity is immensely increased, and greater colour is lent to the probability of the bones being those of a large extinct bird. On the other hand, the occurrence in a kitchen midden, brings them within the human epoch, lessens the likelihood of their relation to a large struthious extinct bird, and opens up a far more important question, which seems to have been almost lost sight of by the Rev. Tenison-Woods. In the first notice he says, "It is certainly quite extinct, but appears to have been contemporaneous with the natives, for these bones are marked with old scars, &c." The matter is also referred to in the second and third notices.

Granting, for the sake of argument, that the bones from South Australia are those of an extinct large bird, it appears to have escaped notice that we have here the first long-sought for evidence of the contemporaneity, on this continent, of man, and its former gigantic fauna.*

Finally, I would say a few words on the references made by the author to Sir Richard Owen. Mr. Woods says, "Professor Owen has named it *Dromornis australis*;" and again, "it has since been named *Dromornis australis* by Professor Owen, who has found that the bird had formerly a wide range in Australia." Will the author point out one single instance in the writings of Sir R. Owen on *Dromornis* to justify such a statement? There is not a particle of evidence to show that Sir Richard ever heard of Mr. Woods' discovery, saw his Report, or had before him the bones in question. What are the facts? The Rev. Mr. Woods in 1866 ***names*** two tibias and two tarso-metatarsal bones, ***Dromaius australis***, from South Australia. Sir Richard Owen in 1872 ***named***, and in 1873 ***described*** a femur from an alluvial deposit at the Peak Downs, Queensland, ***Dromornis australis***, without any knowledge of Mr. Woods' previous discovery. Subsequently the same palæontologist described a tibia and referred to a pelvis, which he believed to be portions of his bird. The pelvis was from near Mudgee, the tibia from the Mount Gambier Range. Surely, had he any acquaintance with Mr. Woods' discovery, here would have been the opportunity to refer to it, when describing another bone from South Australia.

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* This matter has been touched on by Mr. Woods since these pages have been in the printer's hands. (See *Queenslander*, 1888, xxxiv, No. 091, p. 1100.)

XII.—On the Stratigraphical Position of the Fish and Plant-bearing Beds, on the Talbragar River, Cassilis District, N. S. Wales; by WILLIAM ANDERSON, Geological Surveyor.

[Plate XIV.]

THE shales, containing fossil fish, discovered by Mr. Arthur Lowe, of Wilbertree, occur near the Talbragar River, about twenty miles in a straight line to the north of the old mining township of Home Rule, between Mudgee and Gulgong. Their exact position is marked by the southern boundary of Boyce's Selection, No. 14, Parish of Bligh, County Bligh, which passes in an east and west direction over the outcrop of the fossiliferous beds. The nearest point of the Talbragar River lies about three miles in a northerly direction from the locality where the fossils are found.

The general geological feature of the surrounding district is the prevalence of sandstone and conglomerate, which occurs as a bed of considerable thickness, overlying, with a slight unconformity, a series of sandstones, shales, and thin coals, which form some part of the Permo-Carboniferous system. These beds collectively never attain any great thickness in this district, and, when worn through by denudation, the older Palæozoic rocks on which they rest are exposed. This superficial layer of sandstone and conglomerate forms a horizontal bed, showing false bedding, and no doubt represents the Ballimore, or Dubbo Sandstone of the west, and the Hawkesbury Sandstone of the eastern seaboard. The variation in the thickness of the Coal-measures in this part of the western district is purely local, being due to the irregularity of the surface of the Silurian bed-rock on which they were laid down. Frequently the Silurian rocks are seen to rise so high as to be in close relation to the lower surface of the horizontally bedded sandstone overlying the Coal-Measures, which, in such localities, are very thin or not represented at all; so that, although the whole district has been uniformly covered by the Hawkesbury or Dubbo Sandstone, except in a few localities where the Silurian rocks had been so elevated that they rose as shoals or islands in the Triassic sea, the Coal-Measures on which it rests, only attain a considerable thickness over isolated areas, where there had been depressions in the Silurian bed-rock which formed the surface on which the Coal-measures were deposited.

In the eastern district there occurs, intercalated between the Coal-Measures and the Hawkesbury Sandstone, the Estheria and Narabeen Shales, which latter, as suggested by Mr. C. S. Wilkinson,* may probably be the southern representative of the Clarence Series. In the west these two series of shales are not present, and the frequent occurrence of *Glossopteris* in the shales among the coal-bearing beds below the Hawkesbury Sandstones, both here and in the Dubbo district, would preclude the possibility of their being the equivalents of the Clarence Series, for, so far as it is at present known, *Glossopteris* has not been found to occur in the latter. It seems to me probable that these western Coal-measures, which occur in the basin of the Talbragar River, are the equivalents of some portion of the upper part of the Newcastle Series.

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* Notes on the Geology of New South Wales, by C. S. Wilkinson, F.G.S.—*Mineral Products of New South Wales*, 1887, p. 71.

In the immediate neighbourhood of Boyce's selection there are patches of Tertiary basalt of limited extent, in connection with which occur small deposits of exceeding well-rounded, polished, and water-worn pebbles, chiefly of quartz and a dark siliceous rock containing the remains of plants. This basalt and drift rest upon the horizontally bedded sandstone and conglomerate, but do not (at least now) cover the shales containing the fossil fish.

The fossils which first attracted attention were the impressions of plants, which occurred frequently in the loose blocks of shale which lay scattered over the surface of the hill. Subsequently, the fish remains were discovered occurring along with the plants, and, on closer examination by Mr. Arthur Lowe and his brother, they were found to be quite a common feature in the beds, in fact, of more frequent occurrence than the plants.

When I visited the locality, in the beginning of December, 1888, under the guidance of Mr. Lowe, of Wilbertree, I found that only the detached blocks, sticking in the soil had been broken open, the beds themselves not having been touched; but nevertheless great numbers of specimens were obtained and lay ready for transportation; in fact, these specimens form a large portion of this valuable collection.

The shales in which the fossils occur are thinly-laminated, fine-grained, and ferruginous. When unweathered they are grey in colour, and when weathered light brown, which is due to the decomposition of the contained ferruginous material. The joints and laminæ are frequently covered with dendrites. The results of the weathering of these shales are somewhat peculiar. When fresh, the rock seems to be quite compact, without any visible signs of jointing or lamination, but immediately the weathering action begins, it first picks out the vertical jointing, along which the ferruginous decomposition travels, and from these it passes along the laminæ, and so gradually diffuses itself throughout the rock. Many of the blocks when split open show this progressive decomposition very well, where a vertical joint may be seen marked out by decomposition, which may have travelled half-way across the slab. When unweathered it is difficult to split the rock into laminæ; but after considerable weathering it splits easily into square or rectangular layers, often very thin. The final result of this decomposition is, that each rectangular block, formed by two parallel sets of vertical joints at right angles to each other, shows a concentric colour-banding parallel to the vertical jointing, and consisting of lighter and darker ferruginous layers, which traverse the rock at right angles to its lamination. This discolouration which the rock undergoes, does not materially affect the fossils, which are sometimes of a white colour, and are fairly well preserved As a rule, the bony skeletons of the fish are the only parts remaining, although, in numerous cases, the impressions of the scales, showing their ornamentation, can be readily seen. They are mostly of small size, being, as a rule, only a few inches in length, although a few specimens of larger size occur.

One specimen of peculiar interest was obtained by the Collector, Mr. C. Cullen. It was a very perfect example of an insect, which has been beautifully preserved, and forms one of the earliest evidences of terrestrial insect life that have yet been discovered in Australia.

On no part of the outcrop is there a clear section of the fossiliferous beds, showing their relation to the surrounding sandstone and other rocks. But after a careful examination of the ground, I am inclined to think that what little stratigraphical evidence there is, points to the conclusion that they form an isolated lenticular patch in the horizontally-bedded sandstones, similar to the lenticular beds of grey shale which occur in the Hawkesbury Sandstone near the coast. If this be so, the fish, plant, and insect remains are of Hawkesbury or Triassic age, and, consequently, they belong to the same period as the large collection of fish which were obtained some time ago at Gosford, on the Northern Railway, between Sydney and Newcastle. The present collection of plants and fish from the Talbragar River will form another important addition to the, as yet meagre remains, of the fauna and flora of the Hawkesbury-Wianamatta Series, and will have a special interest from the fact that they are from the extreme western portion of the Hawkesbury basin, where the deposition of the sediment must have taken place in much shallower water than was the case in its eastern portion, from which the Gosford fish were obtained.

Great praise is due to Mr. C. Cullen, who made this large collection under considerable difficulty.

XIII.—On the Examination of an Aboriginal Rock-shelter and Kitchen-midden at North Harbour, Port Jackson; by T. W. EDGEWORTH DAVID, B.A., F.G.S., Geological Surveyor; and R. ETHERIDGE, Junr., Palæontologist.

[Plates XV–XXII]

A ROCK-SHELTER and Kitchen-midden on a small bay at North Harbour called Forty Baskets, and nearly opposite the town of Manly, had been partially investigated by Messrs. P. R. Pedley and J. Davison, when it was suggested that we should follow up their work in a more systematic manner.

North Harbour, like the other inlets of Port Jackson, is formed by the Hawkesbury Sandstone, the shore at the small bay known as Forty Baskets, having a trend of S. 36° E. The margin is here fringed with a foreshore of sand, which, in the bight of the bay, thins out completely against the sandstone, but to the north-west, at the mouth of a small creek, it attains a width of three chains. The distance between the creek and the bight of the bay is one hundred and sixty-six yards. Along this line the Hawkesbury Sandstone rises from the south-west to an altitude of one hundred feet in a distance of about one hundred and thirty yards. At thirty yards back from high water-mark, and forty feet above it, is the floor of the small cave or shelter-rock, its position with regard to the several points being shown on Plate XV.

The kitchen-midden forms a small part of the small flat around the mouth of the insignificant creek at the north-eastern angle of Forty Baskets Bay. It is from sixty to seventy yards long on the south side of the latter, the inclination of the surface, from the foot of the sandstone rise to high water-mark, being a very gradual one (Pl. XV).

The rock-shelter (Pl. XVI, Figs. 2–4) is an overhanging ledge of Hawkesbury Sandstone, facing the north-east, and projecting from the rocky and somewhat steep slope.

The roof consists of a hard bed of sandstone from five to six feet thick, which, owing to the softness and consequently more rapid disintegration of the underlying stratum, has become considerably undercut in places, so as to roof-in sheltered spaces, of which the one now under consideration is sixteen yards long, from six to seven feet high in front, and two to three feet high at the back (Pl. XVI., Figs. 2 and 3). The roof of the cave is much blackened and begrimed with the soot from the smoke of numerous fires; for, to judge from the thick accumulation of ashes on the floor of the shelter, this spot must have been a haunt of the aboriginals for many generations. The roof has a slight dip of about two degrees to the south-east, which is the same as that of the surrounding strata.

The original rock-floor is exposed at its west-north-west end, but towards the east-south-east is covered by an accumulation of refuse material left by the aboriginals, twenty and a half feet long, five feet wide at the west-north-west end, and eleven feet at the east-south-east, at which latter point it is at least two feet thick (Pl. XVI., Fig. 2). This refuse material consists of light grey dusty ashes composed of lime formed from burnt shells and fine charcoal, with a small proportion of sand; and, scattered through the whole mass, though most numerous in the upper nine inches of it, are various edible shells, most of which are fractured and some partially burnt.

The following is a descending section of this deposit at the point where the first skeleton was found by us:—

ft. in.
0 4.—Light grey very loose dust, composed chiefly of burnt lime, charcoal, and a little sand, with edible estuarine shells.
0 5.—Dark grey sandy humus, with shells similar to the preceding.
0 5.—Dark grey loamy sand. The skeletons were buried chiefly in this layer, and reposed on the underlying one.
1 0 (at least).—Dark brown consolidated sandy loam.

The whole of the soil in which the skeletons rested was interlaced with the roots of a tree, *Acacia longifolia* (Pl. XVII.), the trunk of which was twelve inches in diameter near the ground, and six feet distant from the skull of the first skeleton. The tree was thirty-five feet high.

The north-end of the Rock-shelter had already been explored before our attention was called to it, but the southern end was intact, and to this our researches were confined (Pl. XVII. Fig. 2). The whole accumulation within the shelter consisted of fine pulverulent lime and ash-dust mixed with a proportion of humus and fragments of recent species of littoral shells, such as were used by the blacks as food.

The bones found in this deposit were, generally speaking, in poor condition, and some were intermingled and confused, as if disturbance subsequent to their original deposit there, had taken place. The friable condition of some can probably be accounted for by the quantity of lime contained in the enclosing earth, and the heat which the whole mass must have been subjected to during long habitation. We found here the larger portion of a male skeleton, originally placed in a prone position, but so intermingled with the rootlets of the acacia, previously mentioned, that the bones were with difficulty removed. The skeleton was cut off from the remainder of the shelter by a large stone placed alongside, not above, the depth below the present surface of the deposit being not more than nine inches to one foot. The skeleton was lying obliquely downwards, the head lowest, the thigh bones at right angles to the column, and the arm bones tucked under the lower jaw. Those portions removed in anything like a perfect state were the larger limb bones, some of the vertebræ, portions of the pelvis, bones of the feet, and parts of the skull, with the teeth exceedingly worn. With these were split kangaroo bones, and a small siliceous flint instrument. The ash deposit surrounding the skeleton contained burnt bones, and the shells, some partially calcined, of *Mytilus hirsutus*, Lamk.; *Cypræa vitellus*, Linn.; *Patella stramoserica*, Martin; *Trochochoclea zebra*, Menke.; *Nerita melanotragus*, E. A. Smith; *Anomalocardia trapezia*, Desh.; *Minella straminea*, Martin, and *Ostrea maudax*, Gould. Three of the leg bones bear very peculiar markings, which will be referred to later (Pl. XX. Fig. 1). In addition to the skeleton of this man other odd bones and pieces, portions of the skeletons of two other individuals, were found by examining the bulk of the ash deposit, prominent amongst these being a lower jaw almost intact, again with the teeth very much worn down, but quite sound.

The deposit on the shore below, and a little to the north of the Rock-shelter is very different to that of the latter. It consists of a mixture of loam, sand, and charred particles, mixed with broken and decayed shells. The thickness of this deposit does not exceed four feet, and rests on dirty sand.

Immediately above high water-mark on this flat, Mr. P. R. Pedley, on a former occasion found two burials, those of a girl and deformed man, accompanied by a tomahawk and skinning knife, similar to those found by us at Long Bay, near Botany. These interments were covered with large stones in the usual way.

Under the guidance of Mr. Pedley, and with the assistance of Messrs. Shipway and Davison, we commenced trenching operations a little to the south-west of the above graves, and, after a considerable amount of labour, we came upon several covering stones, about nine inches below the surface. Under these we found the skeleton of a full-grown man in a fairly good state of preservation, lying in a north-east and south-west direction, on the left side, and so facing the south-east, but more or less doubled up, the femora being partially drawn up against the body. As lying on its side, the skeleton measured five feet in length, so that allowing for a reasonable contraction, this must be the remains of a fairly big man. It was complete with the exception of the left femur and the arm bones. As in the case of the shelter remains, pieces of split bone, probably kangaroo, were also found, and under the skeleton another small siliceous knife (Pl. XX, Fig. 2*a*).

The bones of the man collected here by Mr. Pedley have not come under our notice, with the exception of the left femur, two tibiæ, and the two humeri, the right being much the thicker and stronger bone. These have been presented by

Mr. Pedley to the Mining and Geological Museum. Those portions of the girl's bones remaining at this date, consist of parts of the skull and jaws, both os ilü, parts of ribs and vertebræ, both fibulæ, an ulna, and other fragments. The epiphyses of the limb bones are unossified, and the teeth, especially the molars, retain the original sharpness of their crown convolutions. This would imply that the bones were those of a young person. These have also been presented by Mr. J. Davison.

Returning to the skeleton exhumed by ourselves, we find that the bones do not call for special comment, with the exception of the skull, and this only in so far as its connection with the position in which the deceased had been put to rest. We have already remarked that the arm bones were missing. But on lifting the head we found the left hand nearly perfect, placed under it, in the most natural position (Pl. XXII), as if the man had been reposing in sleep, with his head resting on the hand. The bones are in apposition with the fingers partially pressed into the orbit, but the terminal digits are wanting. This fact struck us as of so very interesting a nature that steps have been taken to preserve both head and hand in their original state (Pl. XXII).

On the overhanging face of the Hawkesbury Sandstone, forming the roof of the shelter, are what may be termed splash work representations of two human hands, both left hands, so often scattered about places frequented by the aborigines. In this case the hands are represented with the palms pressed to the rock surface, the fingers pointing towards the general expanse of the shelter (Pl. XIX). They are situated at the extreme left-hand, or east-south-east end of the excavation, and when delineated, each was placed obliquely, the thumb being held more or less horizontally, and forming the base line of the figure. The area of rock covered by the hand at the time the work was done, retains the original dark grey colour of the smoke-begrimed roof, while the surrounding rock has been splashed or sputtered over with the ashes from the floor of the shelter, so as to produce a light grey ground, contrasting with the dark grey of the hand. The extreme size was six inches from the thumb-bases to the apices of the fingers, and five inches across the palm and thumb in each case. The hands are eleven inches apart, and each about five feet eight inches above the floor of the shelter.

On a contiguous knoll, or rise, rather more than one hundred and twenty yards to the south-east, and overlooking the entrance to North Harbour, several rounded bosses of sandstone crop out, bearing rude aboriginal sculptures (Pl. XXI). These have much decayed, and the only ones discernable are represented in this plate. Of them, Fig. 2 is the plainest. The longitudinal subdivision down the middle is apparent, and two horizontal bands in the contrary direction. The size is two feet seven inches by one foot three inches, the indented outline being three quarters of an inch thick. The outline is somewhat angular on the left-hand side, and the longitudinal subdivision forks both above and below immediately before its final termination at both ends. The second (Pl. XXI, Fig. 1) is somewhat larger, being two feet eleven inches by one foot six inches, but is precisely similar, with the exception that the centre transverse bands are wider apart and curved. In the third carving (Pl. XXI, Fig. 3), we notice a much more oval outline, a far smaller size, and the crossbars, as in Fig. 2, far apart. These carvings are regarded by some as representing boats, by others fish; but they have quite as much resemblance to shields. It is possible they may be the totemic emblems, or boundary marks of the tribe then frequenting this part of the shores of Port Jackson.

The implements found with these skeletons are few in number but interesting. In the Rock-shelter the only object discovered was a siliceous chip (Pl. XX, Fig. 2). A similar object was also found in the Midden excavation on the shore (Pl. XX. Fg. 2*a*). In both cases the position of the chips was identical, underneath the skeletons of the men. Associated with the remains of the girl and deformed man, exhumed by Messrs. Pedley and Davison, was a small tomahawk, oblong in shape, but without a sharp cutting edge. A portion of another and larger axe accompanied this, obliquely split in half (Pl. XX, Fig. 4). Both were originally travelled pebbles, not representing local rocks, and would seem to have been in course of preparation. They are a hornblendic quartz porphyry. A flat skinning-knife, of Hawkesbury Sandstone, similar to that found by us at Long Bay,* but smaller, was also present; and so was another implement, of the same rock, oval-pointed in shape, and perhaps used for piercing, or it may even be as an ornament (Pl. XX, Fig. 3). Similar implements to this have been obtained by Dr. E. P. Ramsay, from aboriginal interments, in Eastern Australia, but he is unable to suggest their use. The siliceous chips above referred to (Pl. XX, Figs. 2 and 2a) are possibly the knives used for making flesh incisions to raise scars, or may even be circumcision knives. Mr. John Brazier has seen similar chips from Western Australia which were undoubtedly used for the latter purpose.

A number of illustrations of chips used for various objects are given by Mr. R. Brough Smyth,† such as used in making jagged spears, cutting scars, skinning and dressing animals, and fragments struck off in preparing tomahawks. Those now under description, however, appear to us to have been employed in one or other of the former operations.

We have already mentioned that some of the bones taken from the rock shelter bore markings. In Pl. XX., Fig. 1, the left tibia of the prone skeleton, taken from inside the projecting stone is represented. It will be observed that the shin-ridge at its proximal end is transversely corrugated and apparently eaten away. Close inspection shows how very tooth-like these markings are, a few exhibiting a prolonged scar, as if a sharp-pointed edge had been drawn across the bone transversely. We have considered the origin of these indentations from various points of view, whether the work of man, the dog, or any smaller carnivorous animal. It would hardly have been possible for a dog's teeth to leave such marked impressions on a green bone; nor, indeed, do the scars correspond to the teeth of that animal. But a suggestion of Dr. E. P. Ramsay's is probably much nearer the truth, that these indentations are the result of gnawing by rats. This will, in a great measure. coincide with the more or less undisturbed condition of the tibia when found. We also took into consideration the possibility of these markings having been caused through the agency of man, either as a cannibal or by means of a tomahawk; but both views were dismissed as untenable with the evidence at hand.

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* Records Geological Survey, N.S. Wales, I. Pt. I.

† Aborigines of Victoria, 1878, I., pp. 380-382.

XIV.—Remarks on a Fern (*Cycadopteris scolopendrina*, Ratte), from the Wianamatta Shales, near Sydney; by R. ETHERIDGE, Junr., Palæontologist.

[Plate XXIII.]

MR. FELIX RATTE has recently described* a new fern from the Wianamatta shales, which he provisionally referred to the genus *Cycadopteris*, Zigno, under the above name. Mr. Ratte hesitated in the choice of a genus for this plant, between that just named and *Lomatopteris*, Schimper, through the imperfection of his material. The acquisition of a more perfect specimen by Mr. G. A. Stonier, Field Assistant, enables me to supplement Mr. Ratte's description.

In both *Cycadopteris* and *Lomatopteris* the rachis is thick, and naked or winged, the pinnules simple or lobed, decurrent, and more or less confluent, but as regards this last character, less so in the former than the latter. Lastly, in both genera the edges of the pinnules are thickened, but here the resemblance ceases.

In *Lomatopteris* there is but a primary nerve in each pinnule, thick and strong at the base, and insensibly decreasing towards the apex, which it hardly reaches, whilst secondary nerves are quite absent. In *Cycadopteris* on the other hand, both primary and secondary nerves exist. The former, as in the first, are large and thick, holding their size nearly to the apex of each pinnule, where they break up into two or three branches. Like that of *Lomatopteris*, it is more apparent on the inferior surface, but is represented on the upper by corresponding grooves. The secondary nerves are short and bifurcate.

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* Proc. Linn. Soc. New South Wales, 1887, I. pt. 4, p. 1081.

In the description given by Saporta it is difficult to understand the distinction he draws between the marginal thickening of the pinnules in the two genera. In the case of *Lomatopteris*, he says,* they are always thickened by a continuous marginal fold, whilst those of *Cycadopteris* are thickened by a line (*ourlet*), which does not proceed from a fold, but is formed by a flat and cartilaginous beading (*bourrelet*). It is difficult to detect an appreciable difference between these characters.

Mr. Ratte's specimen did not show any trace of secondary nerves, but from the general habit and undoubted apparent similarity to *Cycadopteris*, he provisionally referred it to that genus. The acquisition of the present specimen enables me to support Ratte's determination, for there are decided, although faint, traces of secondary nerves. Our specimen exceeds the original in size considerably. The latter is five inches in length by one and a quarter in breadth, the former is eight and a half inches long by two and a quarter wide. It exhibits twenty-eight pinnules, wholly or in part, on one side, and twenty-six on the other. The rachis is three-sixteenths of an inch wide, whilst the pinnules are on an average one inch long and five-sixteenths wide at the upper end of the pinna, but only three-quarters of an inch in length at the basal portion. In form they are oblong ovate, incised for about one-fourth of their length, but the incision strongly marked, the free edges being indicated by a very apparent delicate border. The central groove, representing the mid-rib of the superior face, is wide and shallow.

Locality and Horizon.—Abel Harber & Co.'s brick works, Alexandria, near Sydney. Wianamatta Shales, 120 feet above the Hawkesbury Sandstone.

XV.—Report on supposed Caves, with Aboriginal Drawings, on Harris' Creek, and George's River, near Liverpool; by R. ETHERIDGE, Jun., Palæontologist.

[Plate XXIV].

THE first "Cave," which is simply an overhanging Rock-shelter, is situated on the west side of the western branch of Harris's Creek, a tributary of George's River, and one and a half miles south-east of Teesdale's farm (formerly Andrew Moffitt's), Portion No. 18 (c. 19), of the Liverpool Land District, and about ten miles south-east of that township.

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* Pal. Franç., Plantes Jurassiques, 1873, I., p. 392.

The shelter is perhaps fifty feet above the creek bed, in an ordinary rocky escarpment of the Hawkesbury Sandstone. The direction of the scarp is about S. 5° E., the dip of the sandstone about N. 50° W., at an angle of 25°. The length of the shelter is eighty-seven feet, and its height from the floor to the upper edge of the scarp only twenty-two feet. It is a shallow rocky-hollow of two portions, a right and left as the spectator faces it. The former depends for its outline on the dip of the sandstone; the latter has been gradually hollowed out by atmospheric disintegration. On the surfaces of the dip-faces are a number of rude figures, in black charcoal outline, shaded within their margins. Amongst them are discernable an emu, a shark, several smaller fish, and a figure much resembling a *Hippocampus* or sea-horse, but no hands. Some of the figures are drawn on the dip-face of the roof, quite in the angle formed by the union of the latter and the floor, and must have been executed by a draughtsman lying on his back.

On the face of the left-hand portion of the shelter are delineated a dog, fish, birds, and other indistinct objects, with some hideous outlines, more or less human in shape, probably intended to convey the idea of a "devil-devil." Under some portions of these drawings, and produced previously to them, are seven "hands" of the usual type, in all cases the left; each hand of the dirty yellow colour of the surrounding sandstone; but the surface of the latter outside the margin of the figures with the peculiar ashy or smeared appearance usually accompanying these strange signs.

It was stated by Mr. J. W. Brown, of Liverpool, who acted as guide, that his father, Mr. J. D. Brown, was acquainted with the figures fifty years ago, say about 1838, when he was in the habit of frequenting the creek in company with the aborigines.

The floor of the shelter is, in places, sandstone *in situ*, in others, disintegrated sand, but too shallow to allow of burials having taken place.

Now it would appear from the presence of the "hands," which are *genuine*, that this was formerly a Rock-shelter of the blacks, but the drawings in their *present condition* are *spurious*. The charcoal outlines are quite fresh, and correspond in every way with the initials and hieroglyphics of recent visitors, scattered amongst and alongside the drawings. But there is the great probability that these are original drawings touched-up. This opinion is founded on the fact that here and there undoubted outlines, of an older condition, can be traced where the more recent black ones have not accurately followed the older, a view in which I have the support of Dr. J. C. Cox, who formed one of the party. The older outlines were probably executed in black, like the more recent, but have become almost obliterated.

After inspecting this shelter we were conducted to the east side of George's River, on G. Garnock's Portion 59 (C. 50). Here, close to the mouth of a gully running through Portion 92 (C. 699), another shelter was examined in the rocky escarpment of the river. This is seventy feet long by twenty-two feet deep, and ten to fifteen feet high, and is similar in character to that just described. There are no hands visible in this case, and the natural decay of the rock has almost obliterated what drawings there are. They are of precisely the same character as those in the shelter at Harris's Creek, but quite unimproved, and are only visible in dim outline. This, to a great extent, supports my view that the former are original drawings touched-up. The objects delineated are fish, a kangaroo jumping, and the same humanized figure already described.

The conclusion, therefore, to which one is lead are:—That the open hands are the work of aboriginal artists. That the other figures are of considerable age, as evinced by Mr. Brown's statement; but whether executed by the blacks, or some early white living with them, it is difficult to say, but most probably the former. Finally, those in the Harris's Creek shelter have been improved comparatively recently.

PLATE V.

Lepidodendron Volkmannianum, *Sternberg ?*

Fig. 1. A small specimen, with the upper leaf scars more compressed than those towards the base.

Fig. 1*a*. Two leaf scars, somewhat enlarged.

Fig. 2. A leaf scar, somewhat enlarged, taken from a second specimen, in which the compression is still less.

Fig. 2*a*. Another leaf scar, taken from the same example, in which the outline approaches more to that of Fig. 3.

Fig. 3. Two leaf scars of the species proper for comparison with Figs. 1*a*, 2*a* ; *a*, rounded upper margin ; *b*, flat basal boundary line. (*See* Roemer, *Palaeontographica*, iii, t. 7, f. 13).

From drawings by Mr. R. Kidston.

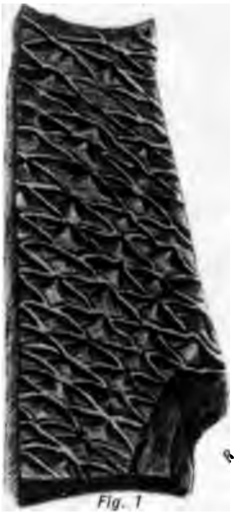

Fig. 1

Fig. 1a

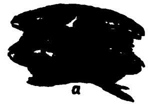

Fig. 2

Fig. 2a

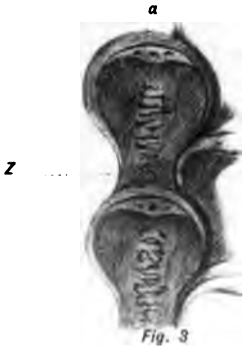

Fig. 3

Reproduced by Heliotype.

PLATE VI.

General view of Bone Camp Gully, Portion 121, Parish of Durham, County Murchison, with the excavations made, as seen from the east side of the creek.

From a drawing by Mr. W. Anderson.

Plate VI.

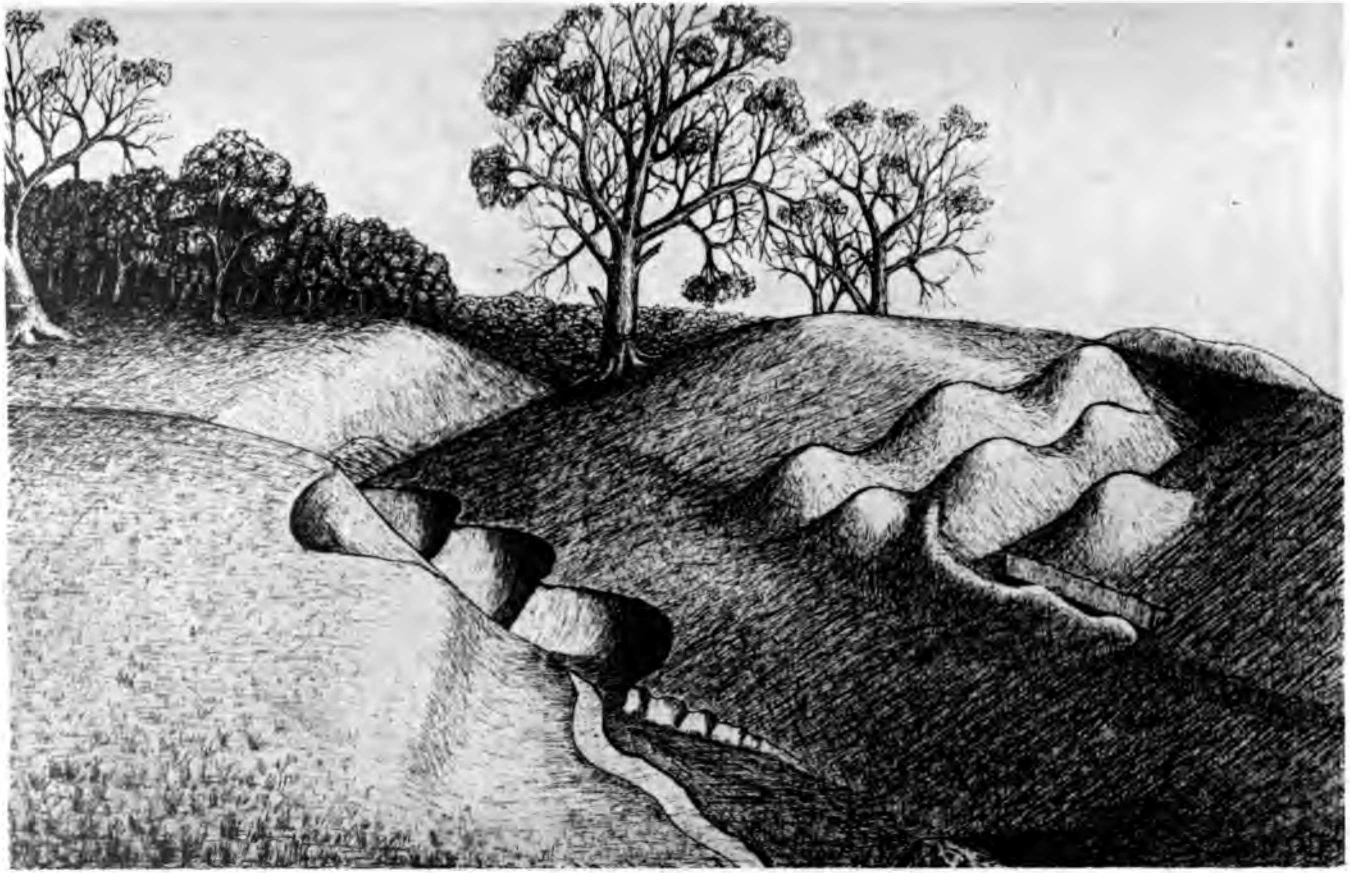

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PLATE VII.

General view of the excavation at Bone Camp Gully, Portion 121, Parish of Durham, County Murchison.

From a drawing by Mr. W. Anderson.

Plate VII.

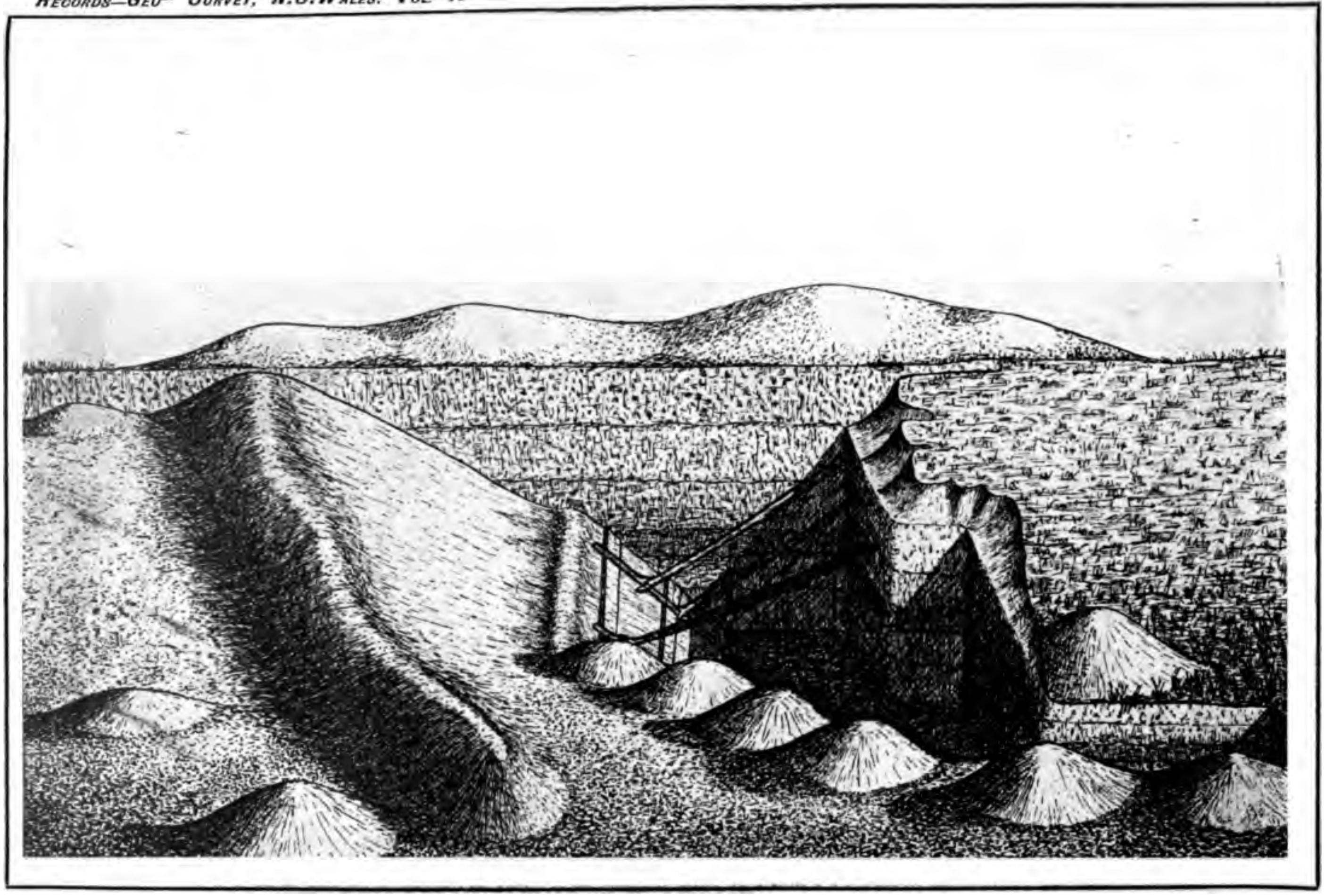

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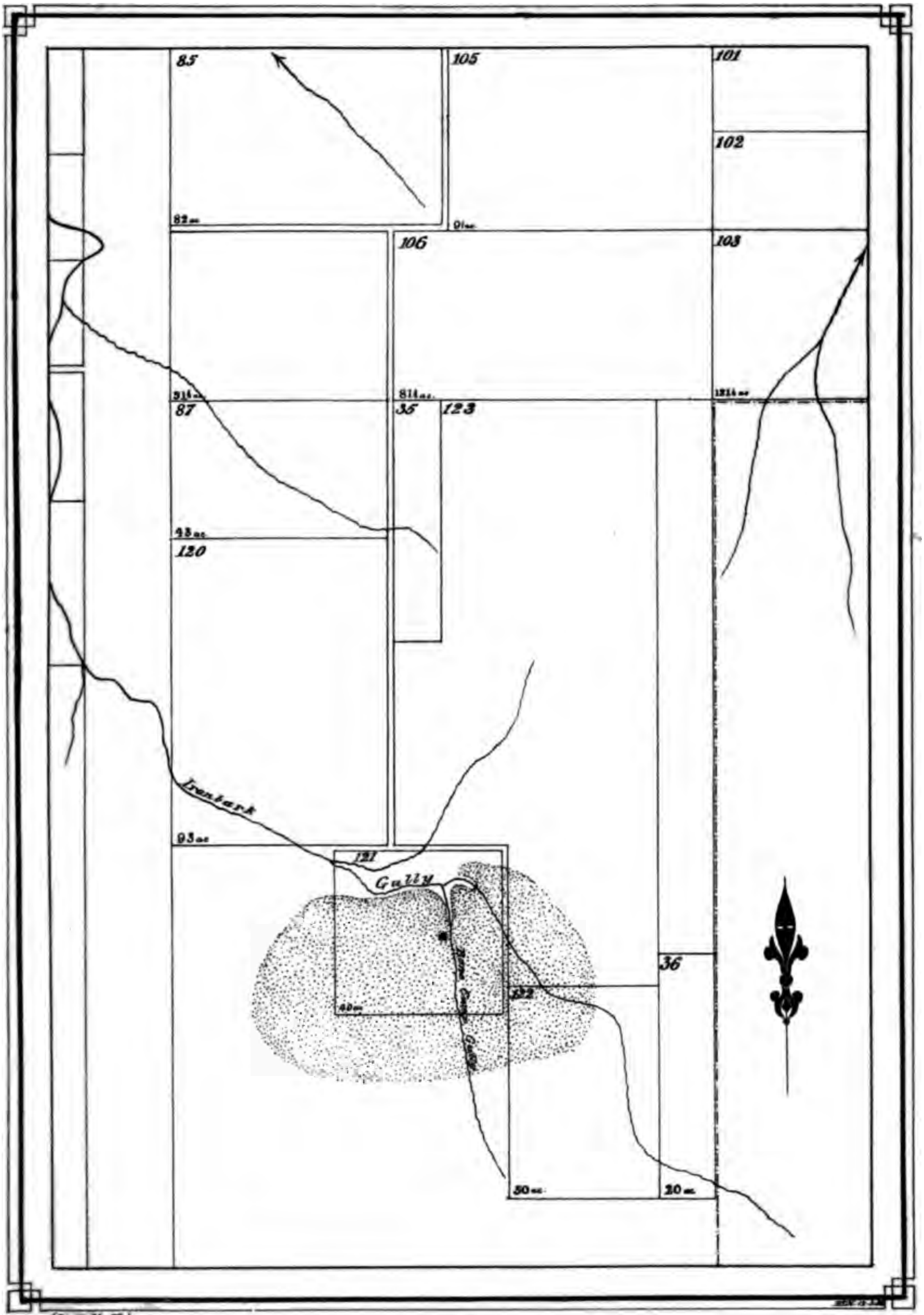
PLATE VIII.

Plan showing the position of the Ossiferous deposit at Bone Camp Gully on Portion 121, Parish of Durham, County Murchison. Scale—eighty chains to one inch.

⁙ Extent of the deposit.

▨ Position of the excavation.

PLATE VIII.



(Sig. 21-89.)

PLATE IX.

Plan of Portion 121, Parish of Durham, County Murchison, showing the outcrop of the bone bed, and associated deposits in Bone Camp Gully. Scale—two chains to one inch.

PLATE IX.

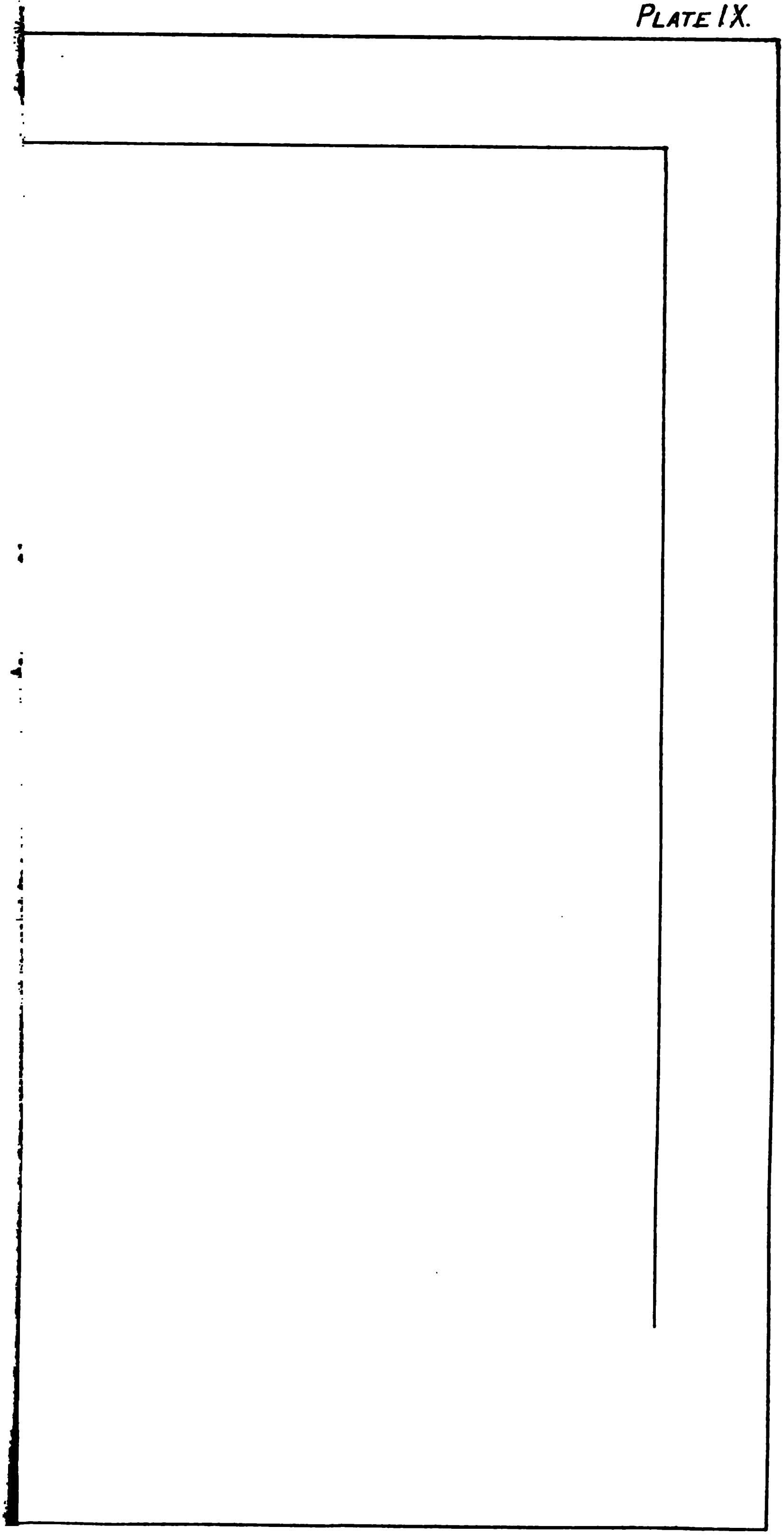


PLATE X.

Sections across the bone bed at Bone Camp Gully showing the order of sequence of the beds.

Fig. 1. North and south section, A to B, on Pl. IX.
Fig. 2. East and west section, C to D, do
Fig. 3. South-east and north-west section, E to F, on Pl. IX.
Fig. 4. East and west, and south-east and north-west section, E to G, on Pl. IX.

Scale—twenty feet to one inch, horizontal and vertical.

PLATE .X.

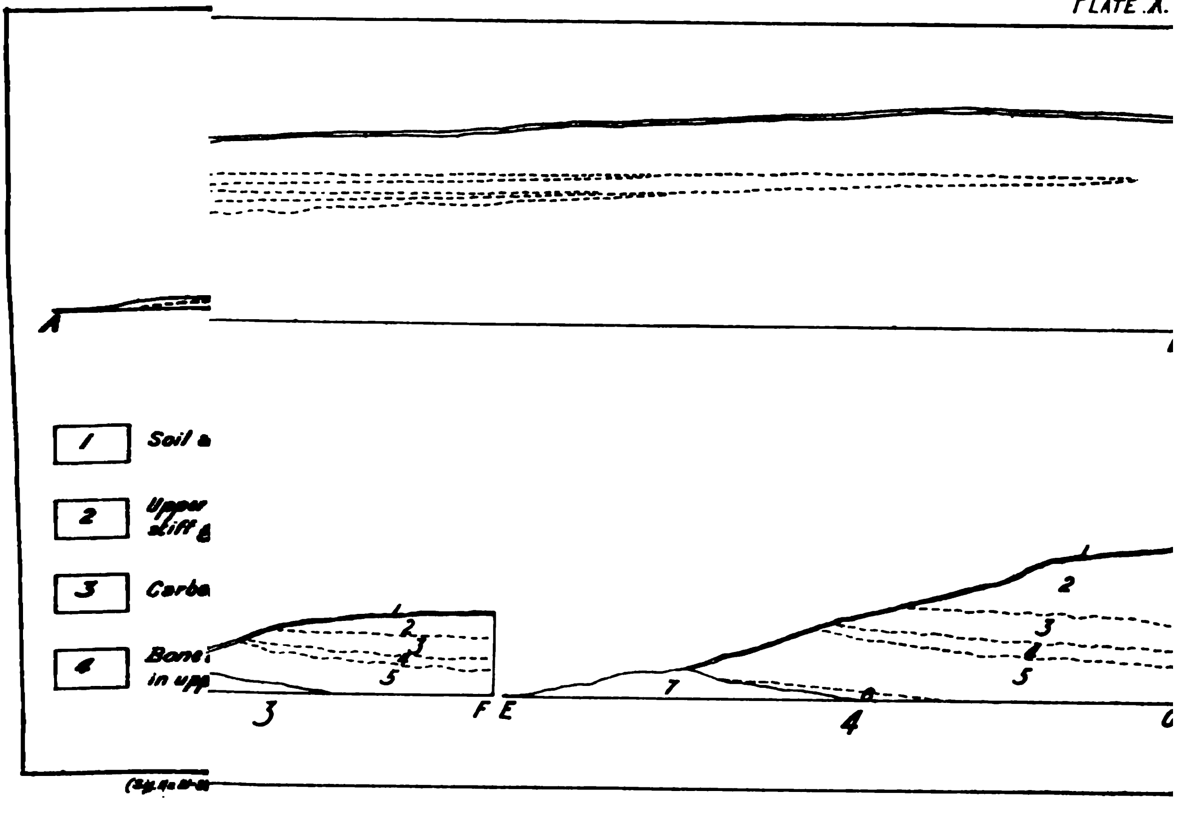

A
Soil a
Upper
stiff
Carbo
Bone
in upp
F E

PLATE XI.

Dromornis australis, *Owen.*

Fig. 1. Distal extremity of the right tibia seen from the inside.

Fig. 2. Proximal end of the left fibula seen from the front.

Dromaius novæ-hollandiæ, *Latham.*

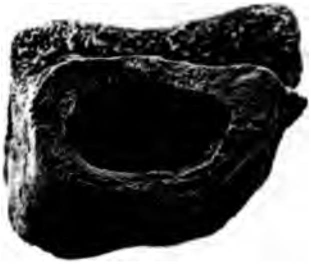
Fig. 3. Distal extremity of the right tibia to show relative proportions as compared with Fig. 4.

Dromaius patricius, *de Vis.*

Fig. 4. Distal extremity of the right tibia to show the large central canal.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are slightly reduced.

4



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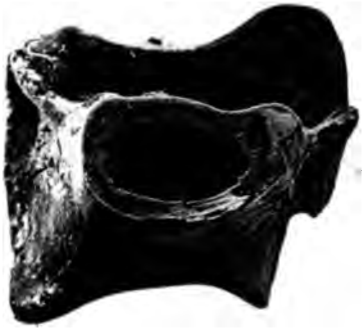

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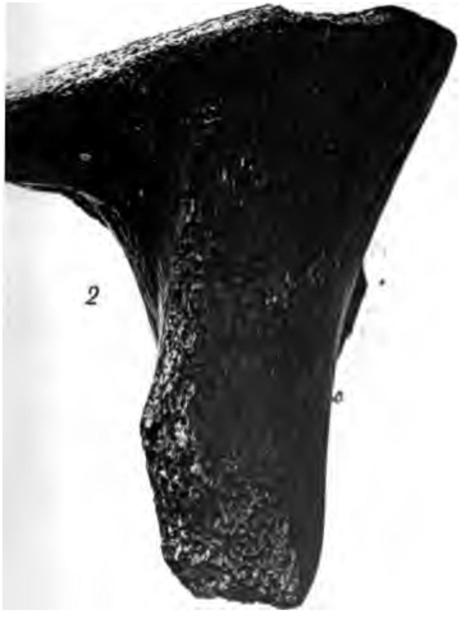

1

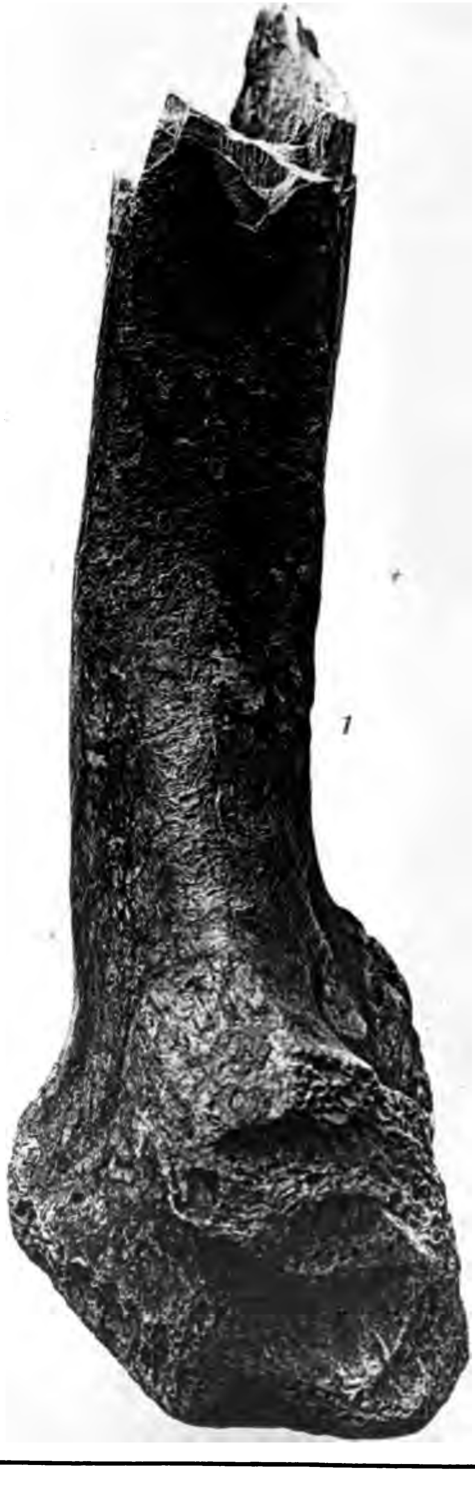

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PLATE XII.

Dromornis australis, *Owen*.

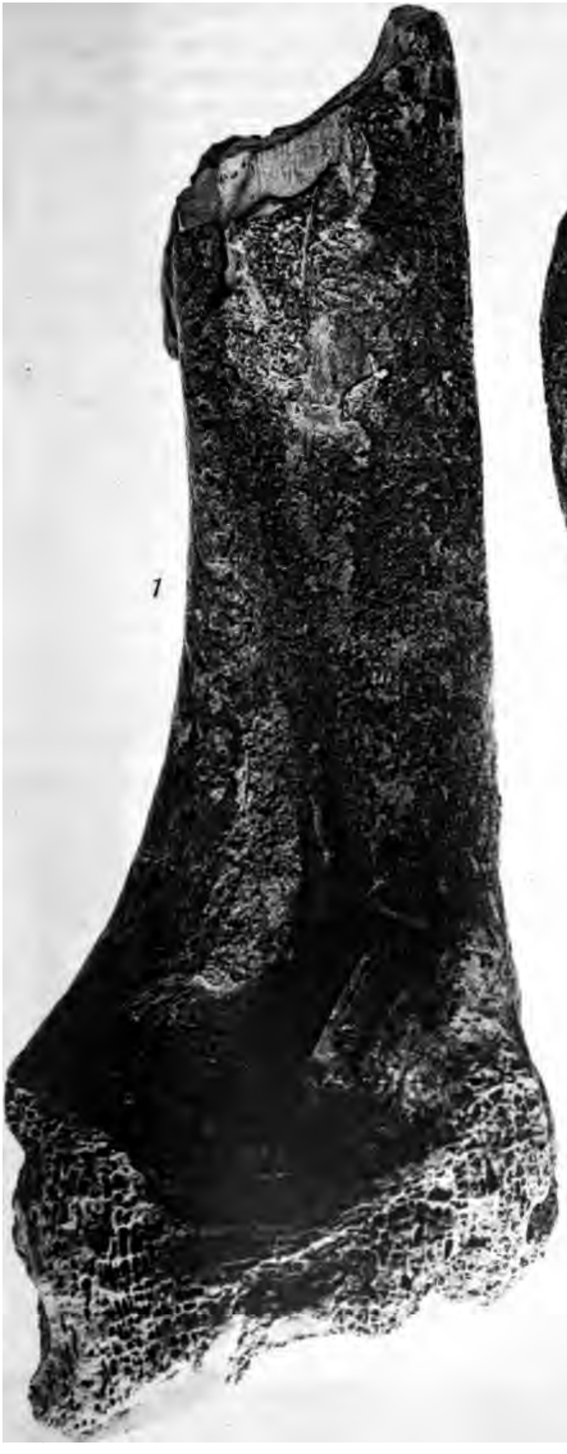
Fig. 1. Distal extremity of the right tibia, seen from the posterior.

Fig. 2. Proximal end of the left fibula, seen from the exterior or outside.

Dromaius patricius, *de Vis*.

Fig. 3. Distal extremity of the right tibia, seen from the posterior.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are slightly reduced.



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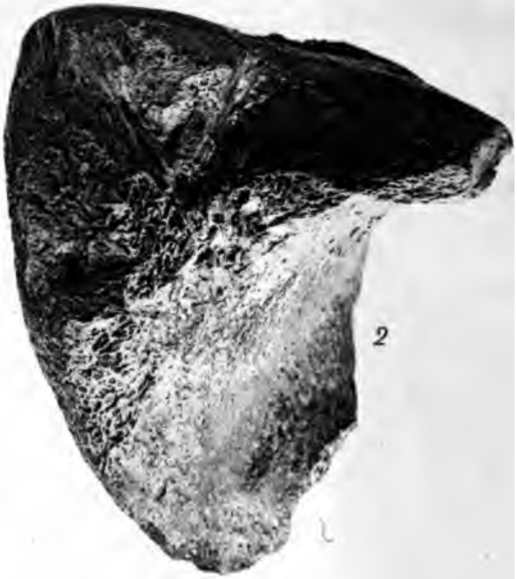

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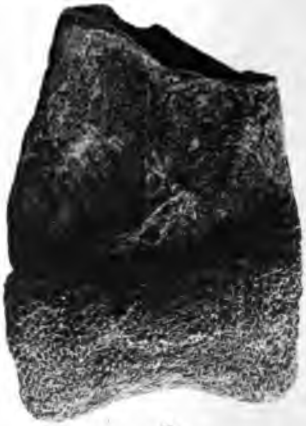


3

Reproduced by Heliotype.

PLATE XIV.

Plan showing the position and approximate extent, so far as traced, of the Fish and Plant-bearing bed on Boyce's Selection and its contiguity to the Talbragar River, in the north-west corner of the Parish of Bligh, County Bligh. Scale—two inches to one mile.

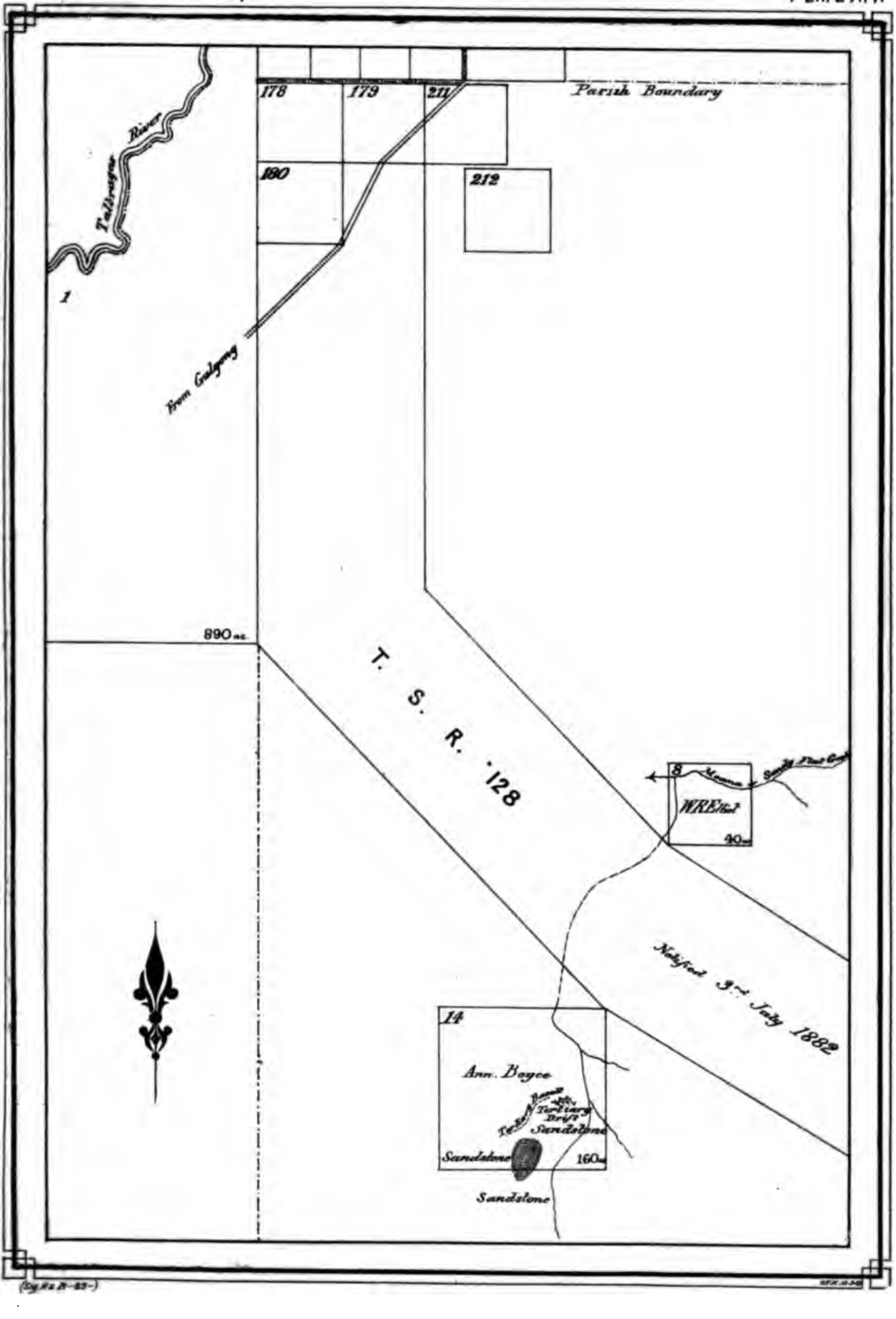

Tallawang River
1
From Gulgong
178
179
211
180
212
Parish Boundary
890 ac.
T. S. R. 128
Notified 3rd July 1882
8
Moonan
Sandy Flat Creek
WREllis
40 ac.
14
Ann. Boyce
Tertiary Basalt
Tertiary Drift
Sandstone
Sandstone
160 ac.
Sandstone

PLATE XV.

Sketch-plan of Forty Baskets Bay, North Harbour, Port Jackson, showing the relative position of the Shelter-rock and Kitchen-midden (A).

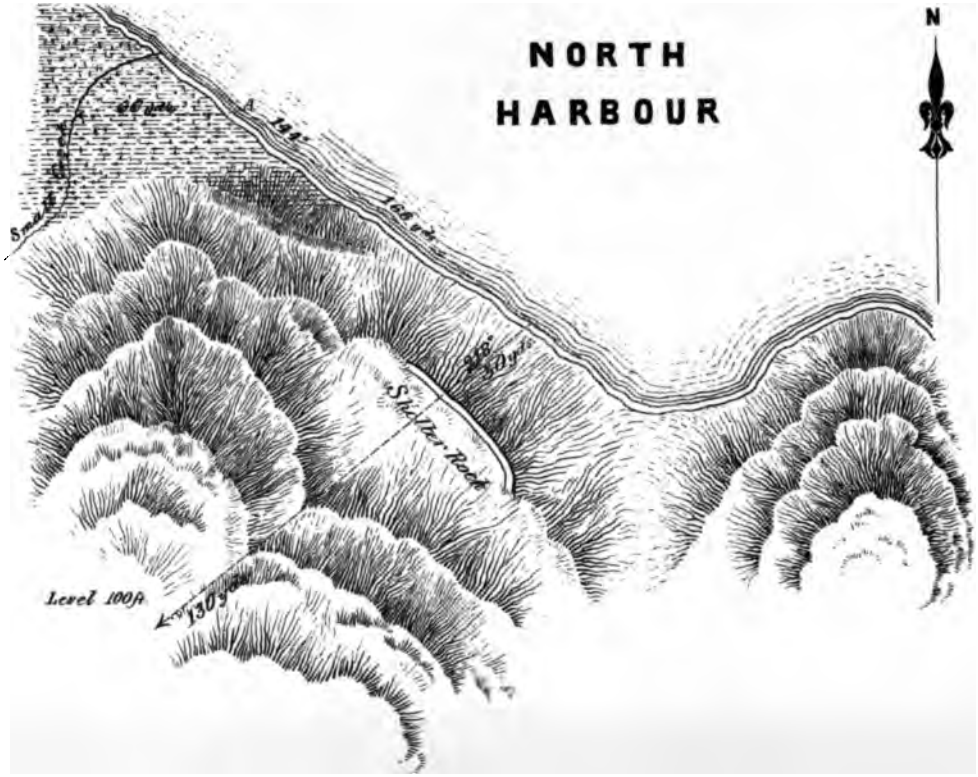

NORTH
HARBOUR
N
Small Creek
60 yds.
A
144°
166 yds.
218°
30 yds.
Shelter Rock
Level 100ft
130 yds.

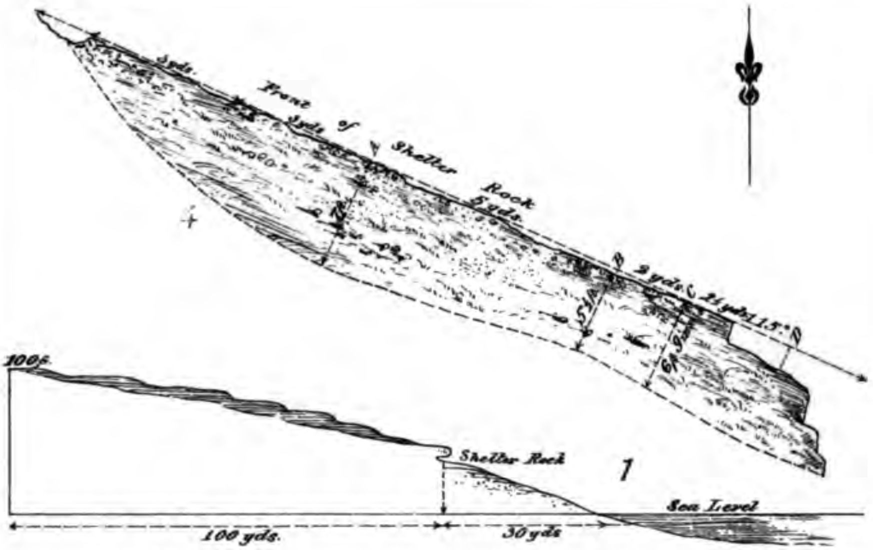
PLATE XVI.

Fig. 1. Generalized section of the shore at Forty Baskets Bay, up to the one hundred-foot level, showing the position of the Shelter-rock.

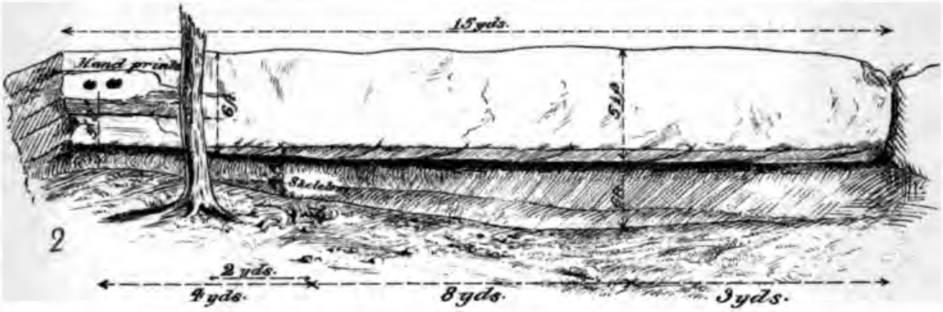
Fig. 2. Front view of the Shelter-rock, showing the relative positions of the skeletons, trunk of the *Acacia*, the hand outlines on the left, and the ash deposit or refuse heap in the foreground.

Fig. 3. Section of the same, taken across the point at which the skeletons were found.

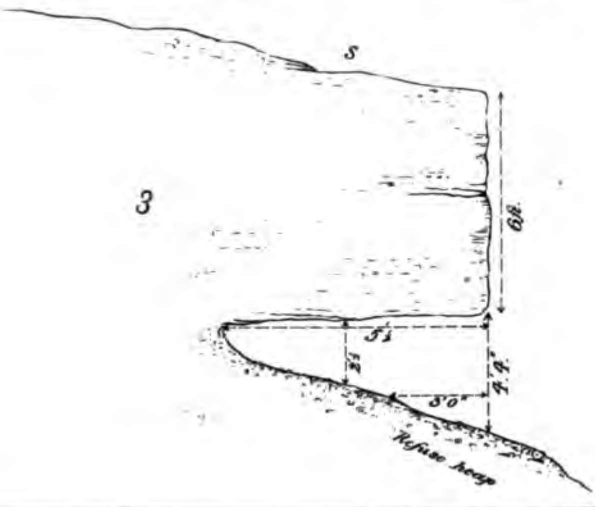
Fig. 4. Ground plan of the Shelter.


A
3 yds.
Front
3 yds of
Shelter
Rock
5 yds.
B
2 yds.
C
2½ yds.
15°
D
100 ft.
Shelter Rock
Sea Level
100 yds.
30 yds

1


15 yds.
Hand prints
Skeleton
2 yds.
4 yds.
8 yds.
3 yds.

2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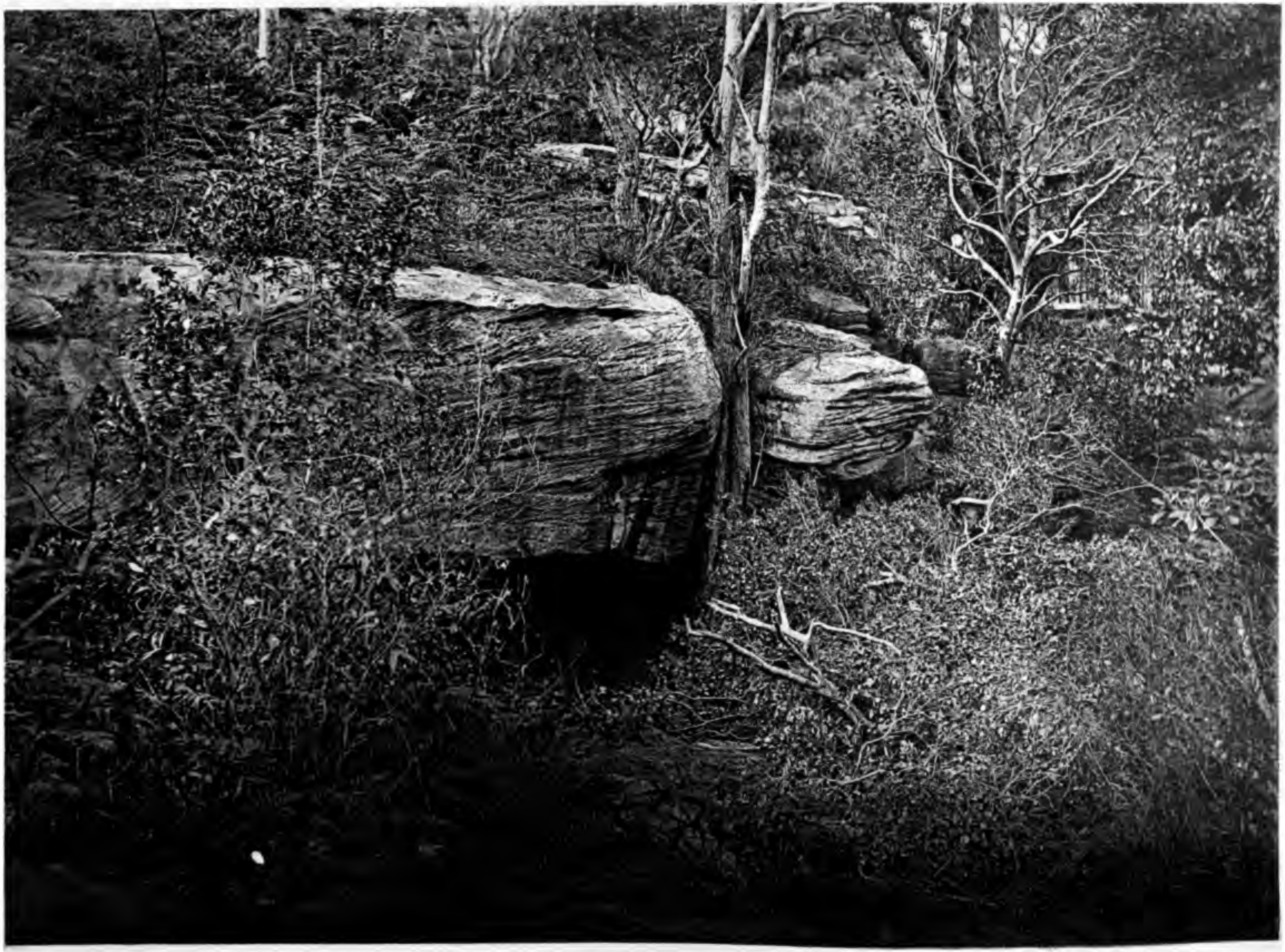
6.8.
5.1.
4.4.
8.0.
Refuse heap

3

PLATE XVII.

View of the Rock-shelter at Forty Baskets Bay, North Harbour, looking slightly from above and the north-east. The trunk of the *Acacia longifolia*, the roots of which were distributed throughout the skeletons, is seen in the centre of the view.

From a photograph by Mr. T. W. E. David.



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OF

PLATE XVIII.

View looking into the Rock-shelter from the north-west, or nearly along its line of frontage. The position of the *Acacia longifolia* marks the south-eastern limit of the shelter.

From a photograph by Mr. T. W. E. David.

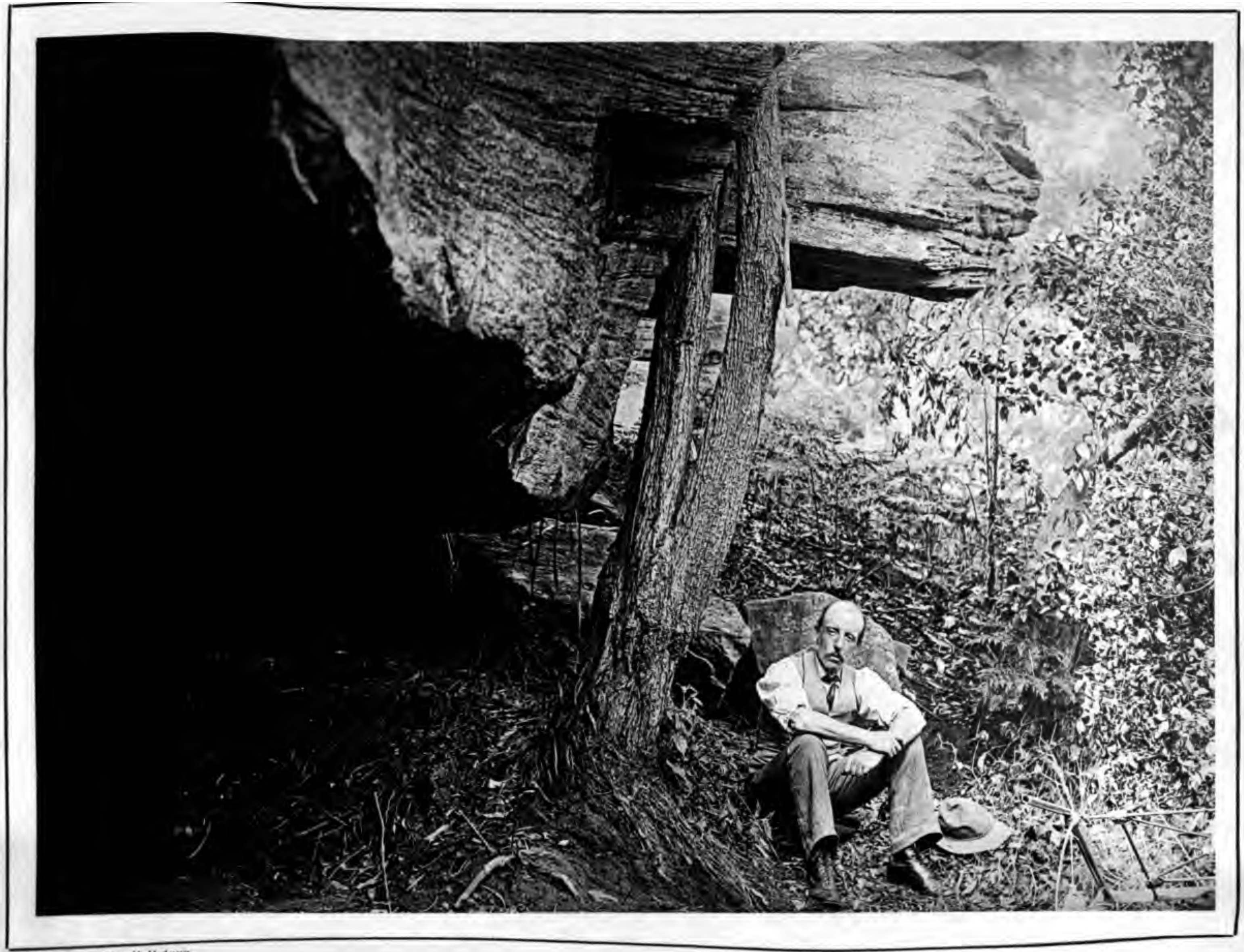

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PLATE XIX.

Surface of the Hawkesbury Sandstone at the south-east end of the shelter, with one of the open hand outlines *in situ*.

From a photograph by Mr. T. W. E. David.

PLATE XX.

Fig. 1. Distal end of a femur from the Rock-shelter, showing the tooth-marks along the anterior crest.

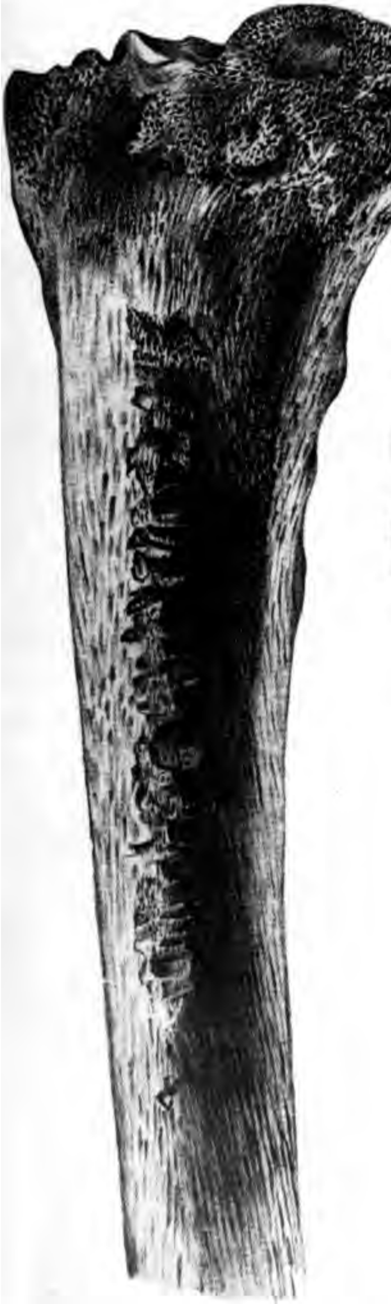
Fig. 2. Small implement of quartzite from the Rock-shelter, found under the skeleton of a man. The rock of which this is formed is unknown in the vicinity of North Harbour. It is probably either a skinning knife, or may have been used in the rite of circumcision.

Fig. 2*a*. A similar implement found in a like position in the Kitchen-midden burial.

Fig. 3. Pointed implement found with the man's skeleton in the Kitchen-midden. It is composed of a micaceous sandstone.

Fig. 4. Broken and roughly-fashioned implement of hornblendic quartz-porphyry, found with another man's skeleton in the Kitchen-midden, by Mr. J. Davison.

The figures are all of the natural size.



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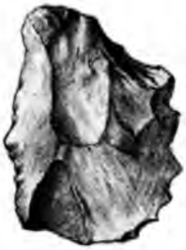

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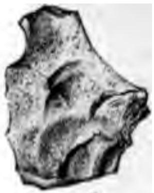

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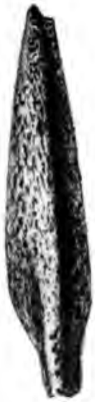

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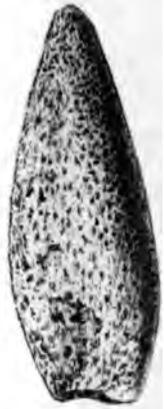

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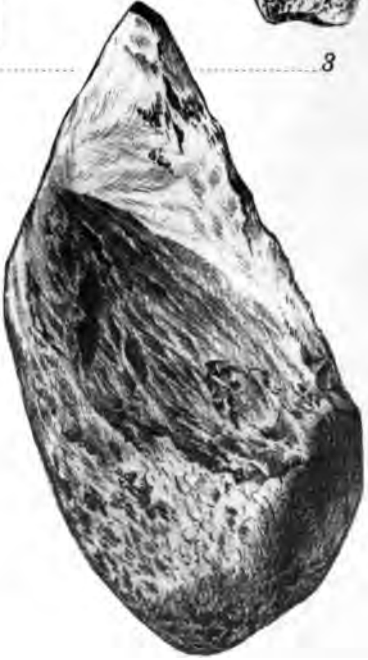

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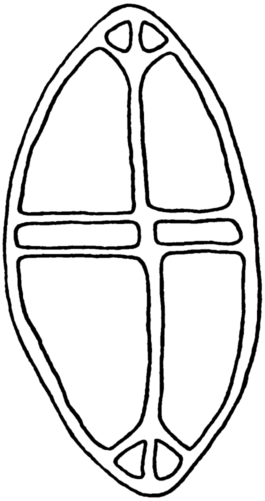
PLATE XXI.

Aboriginal Carvings exposed on the weatherd surfaces of the Hawkesbury Sandstone, near Forty Baskets Bay, overlooking the entrance to North Harbour. Scale—$\frac{1}{12}$ nat.



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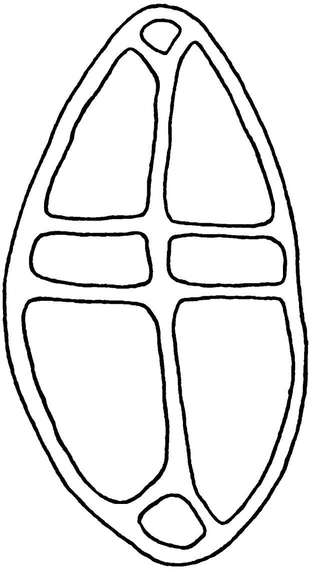

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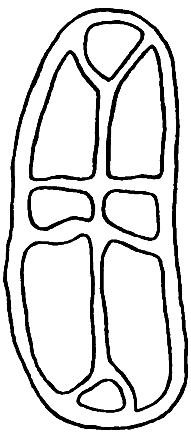

3

P.T. Hammond.

PLATE XXII.

Skull of male Aboriginal, found reposing on the left side in the Kitchen-midden grave at Forty Baskets Bay, with the left hand pressed against the cheek and partly thrust into the orbit. Scale—½ nat.

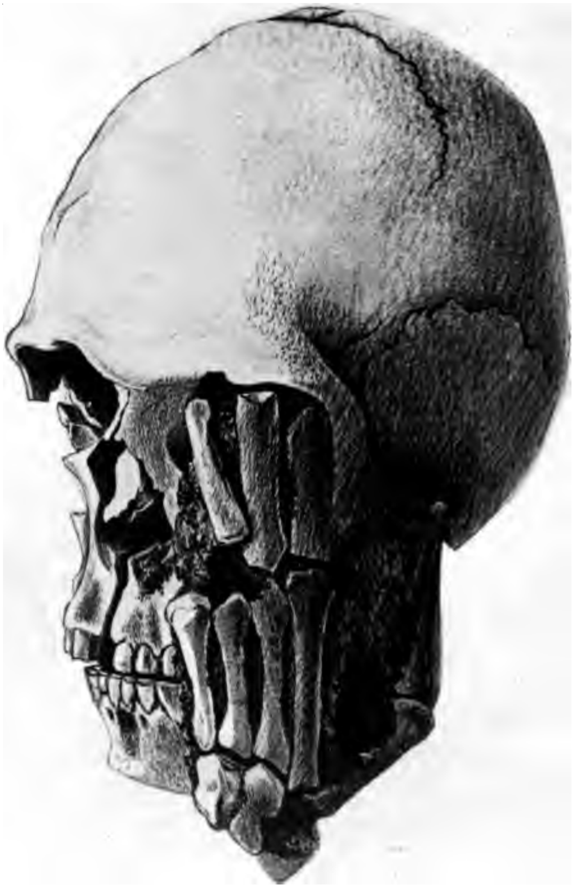

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PLATE XXIII.

Cycadopteris scolopendrina, *Ratte.*

Wianamatta Shales—Alexandria.

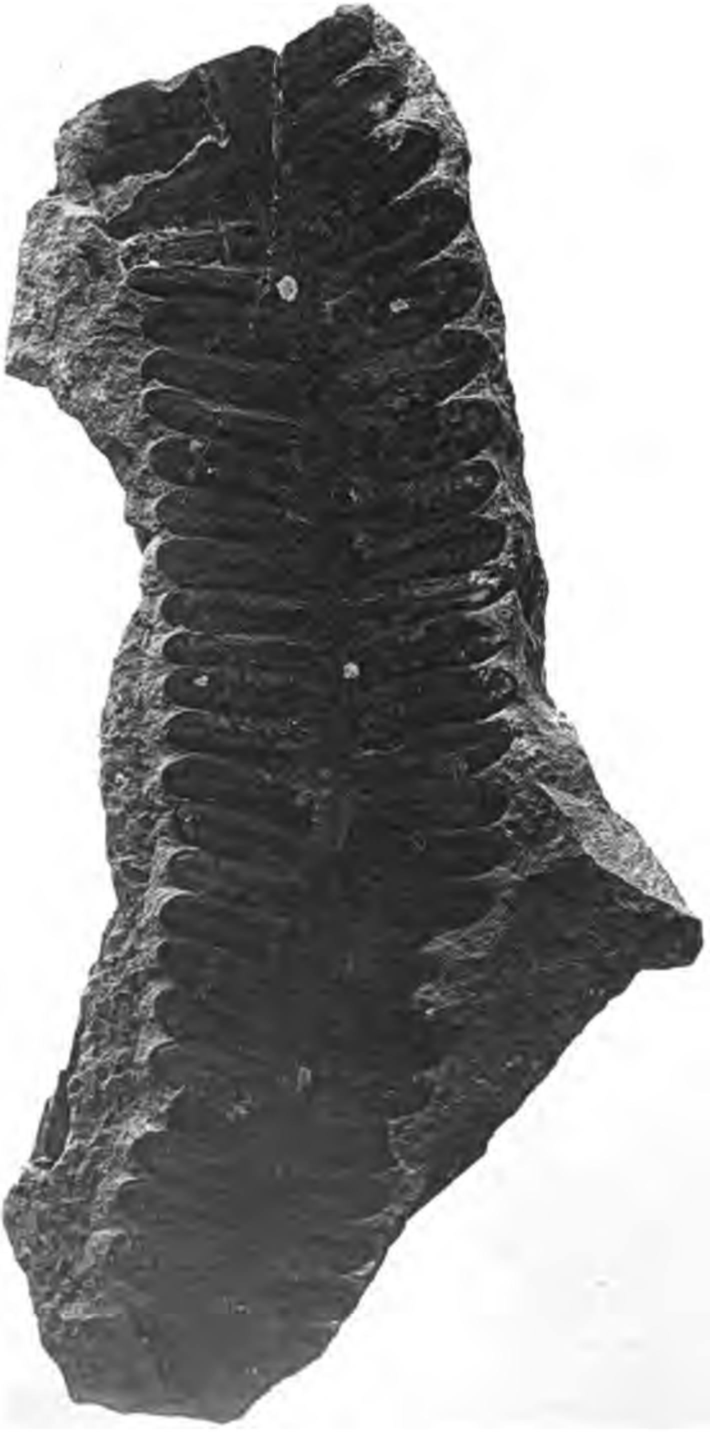

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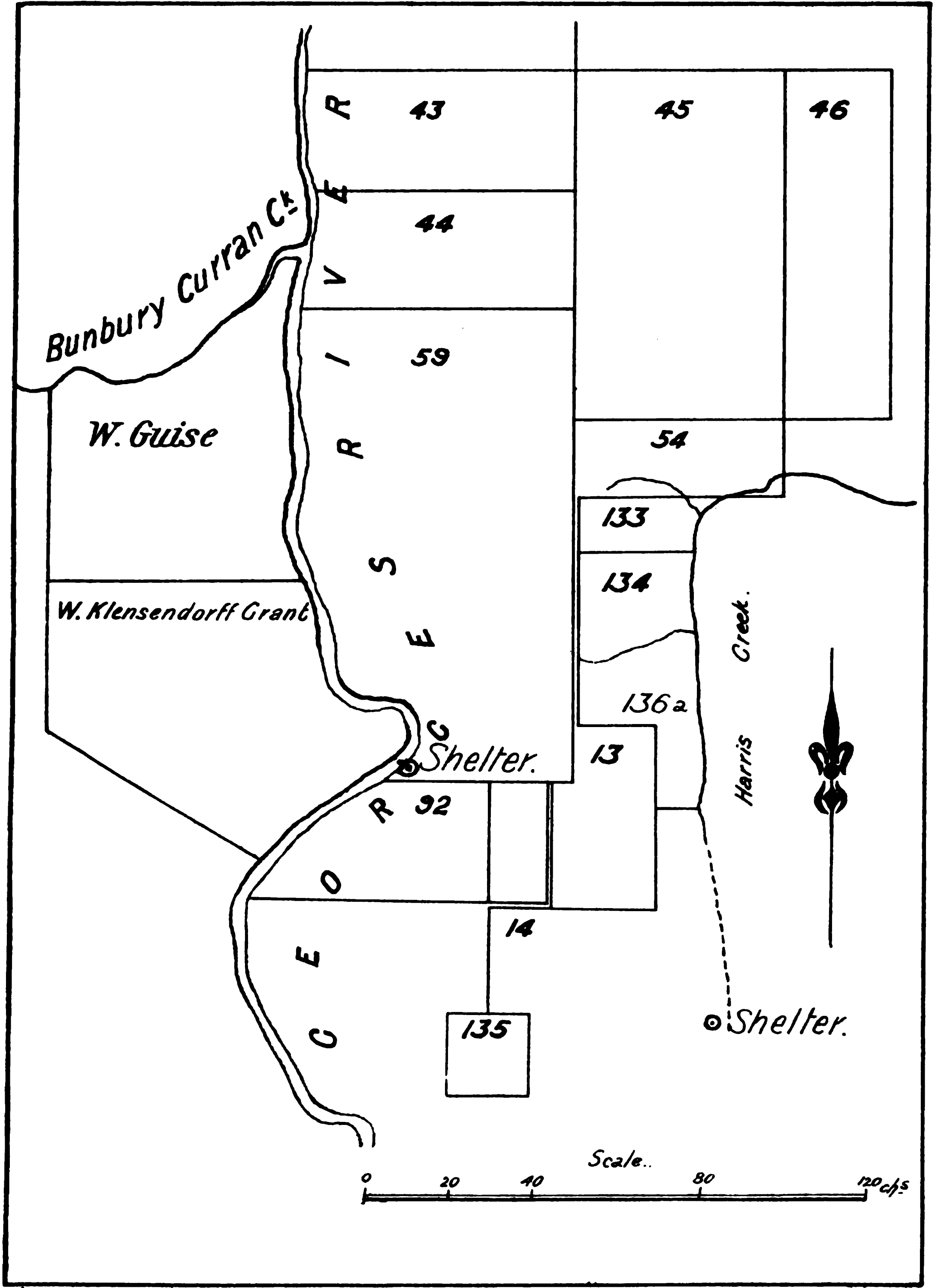
PLATE XXIV.

Plan showing the approximate position of Rock-shelters on George's River, and Harris' Creek, Parishes of Minto and Bankstown, County Cumberland. Scale—forty chains to one inch.

PLATE XXIV.


GEORGES RIVER
Bunbury Curran Ck.
W. Guise
W. Klensendorff Grant
43
44
45
46
59
54
133
134
136a
13
92
14
135
Harris Creek
Shelter.
Shelter.
Scale.
0
20
40
80
120 chs.

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PUBLISHED BY THE

DEPARTMENT OF MINES, SYDNEY, NEW SOUTH WALES,

1ST JANUARY, 1889.

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ALBERT MINING DISTRICT.

h, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.	
	Yancowinna	Thackaringa.	Mount Gipps	Yancowinna	Silverton.	
	do	"The Pinnacles."	Moorkaie	do	do	**Mount Gipps.**
	Farnell	Corona.	Netallie	do	do	
ably.	Yancowinna	Silverton	Purnamoota	do	do	
	do	do	Picton	do	do	**Broken Hill.**
	do	Silverton, Round Hill.	Robe	do	do	**Purnamoota.**
	Farnell	Corona.	Stephen	do	do	
garn	do	do	Soudan	do	do	
[illegible]	do	Poolamacca.	Sebastopol	do	do	**Rockwell Paddoc**
	do	Corona.	Tara	do	do	**Piesse's Nob.**
	Yancowinna	Silverton.	Umberumberka	do	do	
Gap (see Giles).	Farnell		Waukeroo	do	do	
	do	Fowler's Gap.	Yancowinna	do	do	
	Yancowinna	Silverton.				

BATHURST MINING DISTRICT.

h, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
o)	Westmoreland	Wiseman's Creek.	Jocelyn	Westmoreland	Wiseman's Creek.
	do		[illegible]	do	do
	Roxburgh	Sunny Corner.	[illegible]	Bathurst	Ophir Gold-field.
al (do)	do	do	Lewis	do	do
ulen	do	do	Mulgunnia	Georgiana	Mulgunnia Gold-field.
	do	Clear Creek and Kirkconnell Gold-fields.	Oberon	Westmoreland	Oberon Gold-field.
			Tuena	Georgiana	Abercrombie Gold-field.
	do	Sunny Corner.	[illegible]	Bathurst	Ophir Gold-field.
h	Georgiana	Junction Point, Tuena Creek, and Markdale Gold-fields.	[illegible]	do	do
				(Survey Office litho. adopted.)	

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
	Gresham	Boyd or Little River Gold-field. (Survey Office litho. adopted.)

HUNTER AND MACLEAY MINING DISTRICT.

, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
	Gloucester	Barrington Gold-field.	Craven	Gloucester	Barrington Gold-field.

LACHLAN MINING DISTRICT.

, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
rrah	Bland	Temora Gold-field.	Parkes	Ashburnham	Billabong Gold-field.
g	Ashburnham	Billabong Gold-field.	Young	Monteagle	Burrangong Gold-field.

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
[illegible] (a)	Philip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field
[illegible] (b)	do	do	Wyadra	Philip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

rvel	Gough	[illegible]	Lord's Bed (o)	Gough	Emmaville Gold-field.
[illegible]	Clive	do	[illegible]	do	do
[illegible] (a)	Gough	do	[illegible]	Buller	Wilson's Downfall.
[illegible] (b)	Buller	Wilson's Downfall.	[illegible]	do	do
[illegible] (c)	Clive		Paradise North (r)	Gough	Emmaville Gold field.
[illegible] (d)	do		[illegible]	Clive	
owman (e)	do		[illegible]	Buller	Wilson's Downfall.
inghi (f)	do		Rock[illegible]	Clive	Emmaville Gold-field.
oorook	Buller	[illegible] Gold field.	[illegible]	do	do
[illegible] (g)	do	do	[illegible]	do	do
ory (h)	do	Wilson's Downfall.	[illegible] (v)	do	do
alhendore (i)	do	do	[illegible]	do	do
ranbrook (j)	Clive	[illegible] Gold-field.	Stannum	do	do
ellanyn	Buller	[illegible]	[illegible]	do	do
umaresq (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
raser (l)	do	Emmaville Gold field.	[illegible]	Buller	Wilson's Downfall.
lagstone	do	do	[illegible]	Gough	Emmaville Gold field.
[illegible] House	do	do	[illegible]	do	do
[illegible]	do	do	[illegible]	Buller	Wilson's Downfall.
[illegible] (n)	do	Vegetable Creek.	[illegible]	Drake	

PEEL AND URALLA MINING DISTRICT.

[illegible]	[illegible]	[illegible]	[illegible]	Darling	[illegible]
[illegible] (a)	[illegible]	[illegible] Gold field.	[illegible]	Murchison	[illegible] Gold field.
ingera (b)	do		[illegible]	Hardinge	Cope's Creek.
[illegible] (c)	Gough		[illegible]	Gough	
[illegible] (d)	do		[illegible]	Murchison	[illegible] Gold-field.
[illegible]	do		Metz	Sandon	Hillgrove.
live	do	Cope's Creek	[illegible]	Parry	Peel River Gold field.
lare	Hardinge	do	[illegible]	Hardinge	Cope's Creek.
ope's Creek	do	do	[illegible] (m)	Gough	
[illegible]	Clarke		[illegible]	do	
[illegible]	Sandon	Hillgrove	[illegible]	Gresham	Mitchell River.
arby	Hardinge	Cope's Creek.	[illegible]	(see New England Mining District.)	
[illegible] (f)	Parry	Peel River Gold field.			
[illegible] (g)	Murchison	[illegible] Gold field			
[illegible] (h)	do	do [illegible] Gold field.	Tienga	Hardinge	Cope's Creek.
[illegible] (i)	do	do do	[illegible]	Gresham	Mitchell River.
erbert	Gough	Cope's Creek.	[illegible]	Darling	Ironbark Gold field.
anning	[illegible]		Wellington Va[illegible]	(See New England Mining District.)	
all (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
[illegible]	Argyle	Nerrimunga Gold field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
[illegible]	Wellington	Hill End and Tambaroora.	[illegible]	Wellington	Hill End and Tambaroora
[illegible]	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

[illegible] (a)	Wynyard	Adelong Gold field.	Ellerslie (e)	Wynyard	Adelong Gold-field.
[illegible] (b)	Murray	[illegible]	[illegible] (f)	do	do
[illegible] (c)	do	do	Gadara (g)	do	do
[illegible]	Wynyard	Adelong Gold field.	Wondalga (h)	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. 1, PART III.

1889.

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4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

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Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales; and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)

Records of the Geological Survey of New South Wales.

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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. 1.] 1889. [Part 3.

XVI.—On the Occurrence of the Genus *Meiolania* in the Pliocene Deep Lead at Canadian, near Gulgong: by R. ETHERIDGE, Junr., Palæontologist.

[Plates XXV and XXVI.]

So FAR as I am aware neither the remains of the large extinct Lacertilian *Megalania (? Varanus) prisca*, Owen, or either species of the horned Chelonian *Meiolania* have so far been found in any of the New South Wales Pliocene or Post-Tertiary deposits. Both genera were met with in accumulations of the latter age in Queensland, and the last named at Lord Howe Island.

During a preliminary examination of some vertebrate remains from the Canadian Lead, Gulgong, presented to the Mining and Geological Museum by Mr. Philip Snayse, of Gulgong, I was struck by the number of bony plates which appeared to be broken fragments of a Chelonian carapace. Amongst these, however, four bones awakened the keenest interest, from their instantly recalling corresponding portions of the bony framework of Sir Richard Owen's genus *Meiolania*. The specimens are a small horn-core, the greater part of a caudal vertebra, and two portions of two of the annular segments of the tail-sheath.

The controversy over the affinities of these highly interesting genera has been admirably epitomised by Mr. A. Smith Woodward *, and the synonomy corrected. From his remarks it appears that the name *Megalania* must be restricted (if indeed the bones so named are distinct from *Varanus*) to Lacertilian vertebræ from the drift deposits of Darling Downs, and for which it was originally proposed.[*] On the other hand, the Queensland horned skull, hypothetically placed with these Lacertilian vertebræ, must be transferred to Owen's later described genus *Meiolania* [†], created specially for a like skull from Lord Howe Island.

---

* Ann. Mag. Nat. Hist., 1888, I., p. 85.

The *horn-core* (Pl. XXVI, fig. 4) is a small bone, measuring exactly 1$\frac{4}{16}$ inches in both directions with a basal diameter of 1$\frac{3}{16}$ inches, the base having an expanded flange-like appearance. The anterior margin of the base is rather convexly curved, the posterior more concavely excavated. The apex of the core is blunt, and compressed laterally, the entire core being but little curved in a vertical direction, but when placed in a natural position on its base, there is a decided inclination backwards. The surface is deeply and strongly pitted and grooved with neuro-vascular markings. This horn-core corresponds in miniature with the cranial cores of the *Meiolania Owenii*, Smith Wood. [‡], or the smaller ones of *M. platyceps*, Owen. [||]

The two portions of the *annular ring of the tail sheath* (Pl. XXV, fig. 2, Pl. XXVI, fig. 2) are probably derived from the anterior end of the tail as they do not show any sign of having formed a portion of the anchylosed terminal cap. One bears a single boss, the other carries two. These are blunt and conical processes, with their posterior faces vertical and abrupt. Both bones are equal in size, although differing in outline, and measure 2$\frac{1}{16}$ inches in breadth, by 1½ inches in length. The thickness of the bone of the former along the posterior edge at the centre of the boss or core, is half an inch, gradually tapering away in a smooth convex surface to the almost sharp anterior margin. These processes are rather different in shape to those on the tail of *Meiolania Owenii* [§] being more depressed and less protuberant. The second annular fragment (Pl. XXVI, fig. 2) is actually composed of portions of two quadrangular pieces similar to that bearing the one process (Pl. XXV, fig. 2), but with the lateral margins broken away. The line of suture between these two halves is visible, and this may perhaps answer to the "line of confluence" spoken of by Prof. Owen on the upper surface of the tail-sheath of *M. Owenii.*

The caudal vertebra will be at once understood by a comparison with the anterior of those preserved *in situ* in the end of the tail-sheath of *Meiolania platyceps* (Pl. XXV, fig. 1). This exhibits the vertebræ in a much better state of preservation than the corresponding figure given by Sir Richard Owen. When viewed from below, or to some extent sideways, the vertebra is seen to be somewhat hour-glass-shaped, roughly biconate, with the apices towards one another, and sharply constricted by a transverse band in the middle line. It is broadest posteriorly. The centrum is opisthocœlous, roundly ellipsoidal at either end, both the anterior convex, and posterior concave surfaces being well marked; the broadest end of the ellipse is uppermost. The neural ridge is cristiform, thickened posteriorly where overhanging the canal, but tapering off towards the anterior, and becoming sharper. In the present example the apophyseal surface, showing attachment to the exoskeleton is fractured. The neural canal is nearly oval, with a low central ridge on the floor, and extending the whole length. The transverse apophyses, or as they are termed by Owen "buttresses," here partially broken away (Pl. XXV, fig. 3), are confined as in *Meiolania platyceps* (Pl. XXV, fig. 1) to the posterior half of the vertebra. The lateral surfaces of the anterior half of the vertebra are somewhat rounded.

---

[*] Phil. Trans., 1860, cxlix, p. 43.

[†] *Ibid*, 1887 clxxvii, p. 471.

[‡] Owen, Phil. Tran., 1881, clxxii, t. 64.

[||] *Ibid*, 1887, clxxvii, t. 30.

[§] *Ibid*, 1881, clxxii, t. 64.

The hæmal surface is much curved in its antero-posterior length, cut out in the middle line, and V-shaped grooved along its posterior course. The anterior end is rounded off, but as the bone at this point is abraided, it is possible that it also may have been grooved, similar to that of *Meiolania platyceps.* This division of the hæmal portion of the bone now under description, would appear to represent the chevron bones of other groups of the Reptilia, and in more perfectly preserved specimens would form hæmapophyses, or buttresses, for the support of the ventral surface of the bony tail-sheath, or exoskeleton. This is, in fact, well shown at the anterior end of the fracture in the figured tail-sheath of *Meiolania platyceps* (Pl. XXV, fig. 1), from Lord Howe Island.

The general structure of this vertebra from the Canadian Lead, is quite that of the above tail vertebræ of *Meiolania,* but in all probability it would occupy a much more anterior position than any of those here illustrated. Specific identity must remain an open question until we become acquainted with the similar vertebræ of *M. Owenii* and *M. ptatyceps.*[*]

Glancing for a few moments at the tail-sheath from Lord Howe Island (Pls. XXV and XXVI, fig. 1), we observe that the neural and hæmal spines do not seem to show that amount of expansion at their confluence with the sheath anticipated by Prof. Owen. It is a similar osseous subcylindrical sheath to that figured by the latter, with an upper and lower pair of caudal horn-cores, but with the various parts in a more complete state. Owen's specimen was only "sufficiently well preserved to show the elongate subcylindrical shape of the vertebral body, and the reduced area of the neural canal."

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[*] Since these *Meiolania* remains first came under my notice, I have received from Mr. A. G. Hamilton, of the Public School, Mount Kembla, a Chelonian cervical vertebra, obtained from the Canadian Lead. It is, to some extent, imperfect, but, nevertheless, a fair-sized bone, and would appear to be the fifth in the series. As we are not yet acquainted with the similar bone in *Meiolania,* I refrain for the present from referring the specimen to that genus.

In Pl. XXV, fig. 3, these points are also visible, with the supporting buttresses of the exoskeleton, and a more complex "bridge of bone" over-arching the neural canal.

In addition to the remains of *Meiolania* herein described, the Mining and Geological Museum has been enriched by the presentation of many fragments of the carapace and plastron of at least one species of fresh water turtle, perhaps more, from the Canadian Lead. The plates resemble those of the existing *Chelodina*, and amongst the specimens can be recognized marginal carapace pieces, and the right and left pectorals and abdominals of the plastron. They compare most favourably with the similar plates of *Chelodina sulcifera*, Gray, an existing Australian species.

The Canadian Lead, from which the subjects of Pl. XXV, figs. 2 and 3, and Pl. XXVI, figs. 2–4, were obtained, is situated about four and a-half miles from Gulgong, near Mudgee. The length of this lead where worked was 4,660 feet, and the width that proved payable, was from 300 to 500 feet. The sinking averaged about sixty-five feet deep.

Speaking of the Upper Tertiary Leads of this district, Mr. C. S. Wilkinson says: "At a period when the deep leads, such as the Black, Moonlight, Caledonian, &c., formed the drainage channels of the country, and when the banks of those ancient streams were covered with luxuriant vegetation, amidst which the gigantic Diprotodon and other (now extinct) animals found genial pastures, an outflow of lava from some point of eruption came flowing down from a northerly direction . . . covering up the leads as far as the level of the ground would admit it. . . . . Some of the molten basalt spread up the valley for about a mile, while the rest flowed down it in a semi-fluid mass, about 150 feet thick, partly filling the valley for some 20 miles further on. . . . . In most of the leads vegetable fossils, trunks of trees, leaves, nuts, ferns, &c., are found. In the auriferous gravel in Black Lead, beneath the basalt, at a depth of 160 feet, and also at Home Rule, at 130 feet, these fossils are very abundant."*

The remains of *Meiolania Owenii* from Queensland, were found in alluvial deposits, probably of Post-Tertiary age, whilst those of *M. platyceps*, from the Coral-sand rock of Lord Howe Island, are certainly of that age. The present bones, however, must, from their stratigraphical position, be referred to the period of the Pliocene Gold Drifts, and are the oldest known remains of *Meiolania* yet discovered.

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* Annual Report, Department of Mines, New South Wales, for 1876 [1877], p. 171.

XVII.—The Leucite-basalts of N. S. Wales: by T. W. EDGEWORTH DAVID, B.A., &c., and WILLIAM ANDERSON, Geological Surveyors.

[Plates XXVII and XXVIII.]

I.—Introduction.

LEUCITE, as a rock-forming mineral, is of very restricted occurrence. It is present as an essential mineral in leucitophyres (sperones), leucotephrites, and leucitites, and as an essential or accessory mineral in some basalts, trachytes, and phonolites. When leucite is so abundant in the three last-mentioned rocks as to form a distinguishing characteristic, the term leucite is added as a specific or varietal prefix to the generic term basalt, trachyte, or phonolite.

So far as is at present known its occurrence is chiefly, if not wholly, confined to lavas of subaerial or subaqueous origin.

Leucite rocks, although widely distributed, occupy a very small superficial area, being restricted to small isolated lava-sheets in localities far distant from one another, and few in number, only one or two being known in Asia, Africa, North and South America, and Australia. Leucite was unknown as a rock-forming constituent outside Europe until within a comparatively recent date. It has now been found to occur in North and South America, Africa, and Asia. In Asia, until the latest discovery of leucite in Australia, only two localities were known, Java, and the north-west of Persia. In 1885 Mr. David, while engaged in making a geological examination of the country between Bourke and Byrock, in connection with the prospects of obtaining artesian water in that district, discovered the hills of leucite-basalt, near Byrock.* Although this is the first recorded occurrence of leucite in Australia, as far as the authors are aware, it is due to the Rev. J. Milne Curran, F.G.S., to state that he knew of the existence of leucite-basalt at Byrock probably at an earlier date than that of Mr. David's first visit to the locality. The fact, therefore, is that the Rev. J. Milne Curran and Mr. David, working quite independently of one another, discovered the leucite-basalt almost simultaneously. At the end of 1887 the discovery of the El Capitan leucite rock was made conjointly by Mr. Anderson in company with the Rev. J. Milne Curran, F.G.S., then of Cobar.†

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* Mineralogical Magazine, London, 1887, pp. 193-194.
† See Curran, Proc. Linn. Soc. N. S. Wales, 1887, Vol. II., pp. 974-975.

II.—Localities and References.

The following is a list of the known localities of leucite-bearing rocks, together with such references as it was in our power to obtain :—

Localities.

EUROPE.—(1) Capo di Bove, near Rome. (2) Frascatinas, Rome. (3) Monte Somma, near Naples, in prehistoric lavas, earlier than the Plinian eruption of A.D. 79. (4) Vesuvius in lava and pumice from date of Plinian eruption to 1868. (5) Rieden, près du lac de Laach, Eifel. (6) Olbrück, lac de Laach, Eifel. (7) Bongsberg, near Pehn, Eifel. (8) Kaiserstuhl, Baden. (9) Saxony. (10) Bohemia. (11) Thuringer Wald. (12) Rhon Mountain. (13) Wester Wald. (14) Westphalia. (15) Vogelsgebirge. (16) Scania, S. Sweden. (17) Sardinia.

AMERICA.—(18) Pinhalzino, Poços de Caldas, Brazil. (19) Leucite Hills, Wyoming, U.S. North America.

AFRICA.—(20) Cape Verde Islands. (21) Mount Kilimanjaro, Masai Land.

ASIA.—(22) North West Persia. (23) Isle of Bawean, North of Java. (24) Byrock Mountain, near Bourke, N. S. Wales. (25) El Capitan, near Cobar, N. S. Wales.

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H. Rosenbusch : Microscopische Physiographie Wichtigen Mineralien (Stuttgart), 1873.

Dr. F. Zirkel : Die microscopische Beschaffenheit der mineralien and Gesteine (Leipzig), 1873.

(3) and (4), H. J. Johnston—Lavis : Quart. Journ., Geol. Soc., Vol. XL, pp. 35-119.

(4) Haughton and Hull : Transactions of the Royal Irish Academy, vol. XXVI, pp. 49-164.

(18) Professor O. A. Derby : Quart. Journ. Geol. Soc., vol. XLIII, pp. 457-473.

(19) Microscopical Petrography, U.S. Geological Exploration of 40th Parallel (1876), p. 259.

(21) Ueber die Gesteine des Kilimandscharo und dessen Ungebung-Tschermak's Mit. u. petro, g., Mitt. x 1888, p. 236. Hyland.

(23) Neues Jahrb. für Min. 1875, p. 175.

III.—Stratigraphy.

LEUCITE is known to occur in Australia as yet only in two isolated localities, some forty miles apart, on the borders of the Cretaceous plains of the interior of this Colony. One of these is Byrock Mountain, about six miles west of Byrock Township, which latter is situated on the western railway, about fifty miles south-easterly from Bourke, and four hundred and fifty miles north-west of Sydney. The other locality is known as El Capitan, situated in the western corner of the County of Canbelego, about forty miles south of Byrock Mountain. The leucite-basalt here forms a series of small hills with a few outlying hillocks some miles distant. A remarkable feature in connection with the occurrence of these leucite-basalts is the entire absence of any development of basaltic or other lava within a radius of at least one hundred miles of them, the nearest being the small outlier of Tertiary basalt of unknown composition, marked on the map as occurring in the basin of the Macquarie River.

The hills formed of the leucite-basalt present similar physical characters both at El Capitan and Byrock. Their summits and sides are bare of timber and they are locally known as bald hills. When viewed from some distant eminence they are, therefore, conspicuous objects, standing out above the tree-clad plains. There is generally little depth of soil on them, and they usually present a rough, stony appearance from the great number of loose blocks which are strewn over their surfaces. None of them attain any great height above the surrounding plains.

Near Byrock there is one large hill known as Byrock Mountain, which rises about one hundred and thirty feet above the plains, and six hundred and eighty feet above sea level. It is about two miles in length by one in breadth, with three minor isolated rises to the west of it, distant less than two miles. On the largest hill the basalt is thickest at its western end, and gradually thins out towards the east. These are the undenuded remnants of a superficial lava-flow, but as far as our examination went, no evidences of the presence of a crater or orifice of eruption were visible in connection with them. Proofs are not wanting of the existence of old river gravels below the basalt at one point, near Byrock Mountain, and a rounded pebble of Palæozoic quartzite, two inches in diameter was found imbedded in the substance of the lava. About twenty miles to the south of Byrock Mountain, Silurian quartzites occupy a considerable area in the neighbourhood of Coronga Peak, a hill rising nearly one thousand feet above the plains, and it is probable that this pebble may have been derived from these quartzites, and if so, its inclusion in the leucite-basalt may indicate that the lava flowed from the southward. A microscopic examination of this pebble shows that it has been somewhat indurated externally by the lava. The presence of the pebbly drift below the basalt shows that the lava, after its eruption, flowed down an old watercourse, and a comparison of the level at which this drift occurs, with the present general level of the plains, favours the supposition that the eruption could not have taken place within recent times. From an examination of the neighbourhood of the mountain, it is probable that the basalt here rests wholly, or in part, upon granite, which has been intruded among the Silurian slates and quartzites of the district. Outcrops of this granite are seen on the plains to the south of Byrock Mountain, and at the Byrock Waterhole, near Byrock. In the immediate vicinity of the mountain the plains are covered with Pleistocene red soil of variable depth, which generally covers the outcrops of the Silurian slates and granite, as well as a large portion of the isolated basins of horizontally bedded Cretaceo-Tertiary strata, which rest upon and are partially surrounded by them. In this part of the district the aggregate superficial area occupied by the Cretaceo-Tertiary rocks is probably larger than that occupied by the outcrops of the older Palæozoic rocks.

The lava of the Byrock mountain is tolerably dense, even at its upper and under surfaces, and is not locally brecciated like that of El Capitan. A fragment of granite, much weathered, about six inches in diameter was picked up by one of the authors near the top of the mountain, considerably above the level of any of the neighbouring out-crops of granite. Unless this fragment was carried by human agency to the position where it was found, which seems improbable, it was most likely derived from pre-existing hills of the same granite, which now forms the base of Byrock Mountain.

The hill known as El Capitan, is situated in the north-west corner of the County of Canbelego, and is distant thirty-five miles in a north-west direction from Cobar, and forty miles south of Byrock Mountain. The hills of leucite-basalt are here more numerous and of less individual extent, and more detached than is the case at Byrock Mountain. In fact, two or three isolated bald hills, doubtless consisting of leucite-basalt, could be seen some miles off to the south of El Capitan. In outline, the denuded remnants of this basaltic flow are very irregular, so that even an approximate estimate of their aggregate extent and area could not be ascertained, from the necessarily limited examination that could be made of them. Some portions of the rock are very fresh, while others are quite full of amygdaloidal cavities, some of which contain secondary products, and in such positions the individual minerals are much decomposed and altered. In one place the rock presents almost the aspect of a tuff, having a brecciated appearance, and being very full of secondary material. It rests here on the Silurian rocks of the district, which in some places are seen rising to considerable height above the lower levels of the basalt, and represent the sides of the old valley down which the lava flowed. There is also visible below the basalt a considerable amount of cemented river-drift. Thus we have in both localities at Byrock Mountain and El Capitan, evidence to show that the lava on its eruption flowed down an old drainage channel burying the creek bed with its drift below it, and therefore the eruption must have been subaerial.

IV.—Chemical Composition.

The following analyses of the leucite-basalts from Byrock and El Capitan respectively, have been made by Mr. J. C. H. Mingaye, F.C.S., &c., Analyst and Assayer to the Department of Mines :—

	Byrock. I.	El Capitan. II.
Silica	46·43	47·31
Alumina	15·99	18·51
Oxide of iron (Fe_2O_3)	15·04	14·56
Lime ($Ca.\,O$)	9·27	7·57
Magnesia ($Mg.\,O$)	1·74	2·28
Potash (K_2O)	6·93	6·14
Soda (Na_2O)	·51	·98
Phosphoric Anhydride (P_2O_5)	·73	·55
Moisture	3·20	2·31
	99·84	100·21
Sp. gravity of mineral	2·890	2·910

Mr. Mingaye states that both these samples were partly decomposed by hydrochloric acid with the separation of granular silica.

The most remarkable feature about these analyses is the small proportion of magnesia as compared with the abundance of olivine revealed by the microscope.

Estimated by means of drawing the outlines of the olivine, as seen under the microscope, on paper with the aid of a Wollaston's prism, and cutting out and weighing the circumscribed portions of the paper, and reducing the proportions by bulk so arrived at to proportions by weight, the amount of olivine in 100 parts of the leucite basalt was found to be the following:—

In No. 49*a* Byrock, olivine	11·1
In No. 53 ,, ,,	11·3
In No. 59*a* El Capitan, olivine	4·5
In No. 61*a* ,, ,,	6·7

The above results are obviously only approximate. According to the chemical analyses above quoted the amount of magnesia present in the case of the Byrock lava would produce only 3·4 per cent. of olivine, on the assumption of a composition for olivine of 50·90 of magnesia in 100 parts of olivine, and in the case of the El Capitan lava 4·48 of olivine. It would appear, therefore, especially in the case of the Byrock lava, that, even supposing the whole of the magnesia to have been absorbed by the olivines, without, that is, allowing any for the pyroxenes, or mica, there is not sufficient magnesia in the rock to produce the amount of olivine actually present, if the latter were a typical magnesian olivine. Microscopic examination, however, shows that the olivines of the Byrock Mountain are of somewhat unusual appearance, showing well-marked parallel fibrous lines having unusually sharp crystal faces, and being of a yellowish-gray to reddish-brown colour. These olivines are also fringed with the deep reddish brown mineral, evidently of secondary origin, and formed from a combination of part of the constituents of the olivine with the iron of the base of the leucite-basalt. In optical character this mineral somewhat resembles melilite, and is partly soluble in cold hydrochloric acid.

The Byrock olivine may therefore be poor in magnesia, but correspondly rich in lime, and may be a calcareous variety allied to monticellite or leucophanite. A great number, however, of determinations will have to be made by means of the microscope in the manner above described to ascertain the actual average proportion of olivine present, before any positive assertion can be made with regard to the relation of the olivine to the magnesia present in the rock.

Estimated by the same method the minimum amount of leucite present in slide No. 49*a* was 37·5 per cent. by bulk, and 25 per cent. by weight. This result, however is probably below the true quantity, as no account was taken of the very numerous minute leucites, too small to draw.

Assuming that all the potash, given in the analyses, was absorbed by the leucites, there is sufficient potash in the Byrock lava to produce 32·2 per cent. of leucite, and in the El Capitan lava to produce 28·6 per cent.

In the case of slide No. 54*a*, Byrock, the cover glass having been removed and the balsam washed off with spirit, the leucites were treated with cold hydrochloric acid, and the effect watched under the microscope with a ¼-inch objective. It was observed that the surfaces of the leucite rapidly became eroded into a system of anastomosing tubular hollows, similar to those observable in the natural rock in slide No. 50*a* and figured on Plate XXVIII, Fig. 2.

The melilite-like secondary mineral in the same slide, treated in like manner became partially dissolved a trifle more rapidly than the leucite.

The small proportion of soda in the rock, as shown by the analyses, precludes the possibility of nepheline being present, at all events to any appreciable extent, and it may be attributable to analcime and nosean, both of which are probably present. The phosphoric anhydride in the rock confirms the surmise, based on microscopic examination, as to the identity of many of the small prisms, hexagonal in cross-section, with apatite, a fact to which Professor Judd* has already called attention. This is the first record of the occurrence of phosphoric acid in any appreciable quantity in a rock-mass in New South Wales.

V.—Macroscopic Character.

In colour the Byrock rock is bluish-black with innumerable brownish coloured glistening plates of mica scattered through it. In texture it is compact and fine grained and sometimes has a distinctly lamellar structure. Its specific gravity is 2·890. The mica and the olivine are the only porphyritic minerals that are discernible with the naked eye. On weathered surfaces the rock appears rough from the unequal weathering of the various minerals. When struck with the hammer it rings sharply like a phonolite.

The El Capitan rock is more variable in texture and structure than the Byrock. In colour it is lighter being of a dirty grey. Its specific gravity is 2·910. In texture it is usually compact, but in places it is scoriaceous. In at least one locality, however, a considerable thickness of the lower surface of the flow is scoriaceous, and has now become amygdaloidal from the deposition of secondary material in the steam cavities of the scoriæ. The scoriaceous character of the lava at this point has no doubt been due to the fact that it here flowed into the creek or river which occupied the bed of the valley down which the lava flowed. It also presents a brecciated character which gives it the appearance of a tuff, but this is confined to restricted areas.

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* *Mineralogical Magazine*, 1887, p. 194.

VI.—Microscopic Characters.

(a) General.

In general microscopical characters the rock presents a finely crystalline structure, having some of the contained minerals developed micro-porphyritically, some of them, especially the olivines, being even macroscopic. This structure is so well marked that it is justifiable to describe the rock as consisting of a base, in which are imbedded the larger micro-porphyritic crystals. The base consists of a micro-crystalline aggregate of *leucite*, *augite*, and *magnetite* in varying proportions, with occasionally a little glassy material. The minerals which occur micro-porphyritically throughout the base are *leucite*, *olivine*, *mica*, and *nosean* (?). The base varies considerably in comparative quantity in different parts of the rock. In some places it is very abundant, and in others very scanty, where the bulk of the rock is made up of the micro-porphyritic leucite, olivine, and mica the individual micro-porphyritic crystals being separated only by a single layer of augite prisms and magnetite. It consists chiefly of minute leucites, augites, and magnetite with a little glass. The general arrangement of the lath-shaped augite crystals, in the base, is often such that their longer axes are parallel to one another, thus indicating flowage structure. The general texture of the base varies greatly, in some instances being so coarsely crystalline that the structure is almost doleritic, whilst in others it is quite aphanitic. Aggregations of some of the minerals of the base frequently occur forming irregular masses, sometimes surrounded by a border of leucite. Augite and leucite, to the exclusion of the other minerals, are often observable aggregated together. Sometimes the magnetite alone of the base minerals is absent, and often minute fragments of mica enter into the composition of these aggregations—olivine very rarely. Glass is also present in some instances.

Leucite occurs in the rock in great abundance, both in the form of minute, more or less circular crystals in the base, and also micro-porphyritically, but it never attains a macroscopic size. It is generally roughly crystalline in outline, which, however, is usually obscure, and is more rudely circular than polygonal. It is developed generally in individual crystals, which are each surrounded by base, but frequently a series of individuals are grouped circularly around a nucleus which may consist of magnetite alone, or a minute portion of the crystalline base, or of glassy material. It often forms a boundary to the crystalline aggregates formed of the other minerals of the base. The crystals rarely show, under crossed nicols the twin lamellation so characteristic of the large leucites of Somma and Vesuvius, except in a few cases, where it is faintly distinguishable. Inclusions are common, and chiefly consist of crystalline augite, apatite, and magnetite, with many minute circular and oval bodies, which may be glassy beads. Minute pale brownish coloured crystals, generally in hexagonal sections, occur in some of the leucites, and these are very probably noseans. The crystalline inclusions are generally arranged indiscriminately through the leucite crystals, but sometimes they are radially or concentrically arranged. The glass inclusions are generally arranged in a concentric manner. In a few instances the leucite presents a distinctly zonal structure, each octagonal zone being marked out by minutely beaded lines which may be formed of granules of magnetite or glass (?). Very often the centre of the crystal is occupied by a minute black speck, which is probably a crystal or group of granules of magnetite. Such leucite crystals present the appearance as if they had crystallized around the nucleus as.a centre. Some of the leucites, particularly in slides Nos. 50*a* and *b*, present a somewhat curious structure. In many cases nearly the whole section of the crystal is seen to consist of a network of anastomosing tubuli, which occupy considerable areas and bands traversing the crystal. This structure can only be distinctly seen under a high power, and it seems to occur chiefly in leucites in which there are few or no microlithes of augite and apatite, although it also occurs where those are present. In some cases this network can be demonstrated to be only an apparent one, due to the superposition of microliths of apatite (?) which do not lie in the same vertical plane, and whose entire outlines can be seen crossing each other according as each individual is brought into focus. In other cases, however, the tubuli can be seen to be bent, and to present a wavy outline which is certainly not a crystalline outline. From the fact that in section this anastomosing network is usually observed to occupy more or less narrow bands crossing the leucite crystal, it is probable that they have been developed not indiscriminately through the crystal, but, as a rule, along certain planes. It is suggested that this structure may be due to corrosion which acted perhaps along the solution, or possibly the stress planes of the crystal. This structure, as already mentioned, can be imitated experimentally by washing with cold hydrochloric acid, the surface of leucite crystals in microscopic slides, which do not naturally show this structure. Leucite occurs commonly included in the plates of mica, and sometimes it forms more or less amorphous masses, where the individuals are not crystalline, but are irregularly matted together so as, in section, to have the appearance of a mosaic. In some places the rock is so rich in leucite that the base is hardly apparent, but this is very local.

Augite occurs as one of the chief constituents of the base in the form of small lath-shaped crystals, and it is also frequently present in a micro-porphyritic form. It has the yellowish-green tinge characteristic of augite. It often shows twinning and its microliths are about the most common occurring in the leucites. It was probably one of the earliest minerals to crystallize out. Magnetite is a very common inclusion in the augite, and very often the micro-porphyritic augites have a distinctly crystalline outline. It is one of the commonest minerals found in the aggregations. In a few instances the micro-porphyritic augites show a uralitic cleavage. (No. 54*a*).

Magnetite, as a rule, occurs plentifully in the base, generally in the form of individual cubical crystals, but sometimes also in small aggregates. It is also found included in the leucite in minute grains, which often occupy the centre of the crystal, and in most of the other minerals.

Olivine occurs chiefly as a micro-porphyritic form, and very rarely (if ever) as a constituent of the base. It is generally indistinctly crystalline in outline. Of all the minerals it is the one which most frequently shows decomposition. It sometimes takes the form of geniculate twins, and as a rule the crystalline form is generally rounded off, the outline being well marked by a boundary of magnetite. Many crystals are quite fresh and undecomposed, and all gradations can be seen from wholly fresh crystals to crystals which are entirely occupied by decomposition products. The decomposition which the olivine has undergone is somewhat peculiar and unusual. It has not taken place, as is usually the case from the periphery of the crystal inwards along the cracks, but it seems to have progressed from the periphery along lines which lie very close together and are at right angles to the long axis of the crystal, although in some cases the cracks where present also show slight decomposition. The decomposition product is in part serpentinous and in the earlier stages is yellowish-green, but the ultimate alteration is into a reddish-brown mineral which is either allied to a ferriferous mica or to melilite, more probably the latter from the fact that it never shows pleochroism. When this decomposition has only partially taken place it gives the crystal a perfectly fibrous structure. A somewhat similar fibrous decomposition of the olivine has been observed in a dolerite containing porphyritic mica from a small basalt flow in the breach of the crater of an extinct volcano called "The Gap" in the Parish of Lorne, County Gough, Vegetable Creek District, N. S. Wales.

Mica is present generally in the form of macroscopic flakes, and also in small microscopic individuals. They rarely or never have a crystalline outline but are large irregular ragged looking masses. In colour it varies much from deep orange brown to pale yellow. The basal cleavage is strongly marked. Mica often enters into the composition of the aggregations in the form of minute irregularly shaped pieces. The larger flakes are indented by, and include, individuals of all the other minerals, leucite, augite, magnetite and even olivine, but nosean has not been observed in them as an inclusion. Mica must therefore have been the last of all the minerals to crystallize out and has the appearance of having filled up all the irregular spaces which were left by the crystallization of the other minerals.

Apatite occurs only as clear transparent lath-shaped microliths which are very commonly included in the leucite crystals in great numbers. It does not occur in the base.

Nosean (?).—The mineral which has provisionally been identified as nosean occurs as macroscopically porphyritic crystals of rare occurrence, and also as minute well-formed six-sided crystals included in the leucites. In the case of the large porphyritic crystals the mineral has undergone considerable decomposition, being altered probably into analcime. They present a corroded appearance with no evidence of their original crystalline outline. The minute forms included in the leucite are of a pale brownish colour and are perfectly crystalline.

(*b*) *Description of Slides.*

No. 49*a*, from Byrock Mountain. A micro-crystalline rock, composed chiefly of crystals of leucite, with smaller crystals of augite, chiefly prismatic, and still smaller crystals of magnetite. Olivine occurs in granules, often aggregated in groups of two or three, and sometimes large enough to make the rock micro-porphyritic. It is always more or less decomposed, and exhibits a fibrous structure *due to serpentinisation.* Micro-porphyritic plates of yellowish mica occur somewhat plentifully, enclosing crystals of augite and leucite in such a manner as to present the appearance of its having taken the place of the augite and magnetite which occur interstitially between the grains of leucite in the rest of the slide. This mica is strongly pleochroic, and exhibits strong basal cleavage. A well-marked geode ⅓ of an inch in diameter occurs at the margin of the slide, composed chiefly of mica, which in polarised light is seen to be composed of large crystals, but in ordinary light shows only a mosaic of mica, with a few smaller crystals of the same mineral. Intermixed with the mosaic mica in the geode are aggregated crystals of magnetic iron, many of which are invested with a thin coating of leucite. The geode, where it joins the general rock, is partly surrounded by a zone of intercrystallized leucite and magnetic iron with a little augite and mica.

No. 49*b*, from Byrock Mountain. Good inclusions in leucite. Olivine decomposed bottle green to reddish brown. In one part of slide the leucite occurs in an aggregated mass of partially individualized crystals surrounding an oval nucleus of some singly-refracting mineral (leucite or glassy base ?).

No. 49*c*, from Byrock Mountain. An isolated patch of glass surrounded by leucite occurs in this slide.

No. 50*a*, from Byrock Mountain. Leucites perforated by irregular-shaped branching tubuli, apparently produced by corrosion (Pl. XXVIII, fig 2). Edges of all the leucites much corroded. Several crystals of triclinic felspar present, also much corroded. A little mica chiefly found investing the leucites.

No. 50*b*, from Byrock Mountain. A few amygdules consisting of a white partially-opaque secondary mineral, showing plumose structure partly isotropic and partly anisotropic. These have somewhat the appearance of corroded porphyritic decomposed crystals of nosean.

No. 51, from Byrock Mountain. Leucite in well-shaped crystals. Prismatic augite, with abundant magnetite. Olivine in micro-porphyritic grains, remarkably free from decomposition. One aggregation of magnetite surrounded with leucite, with polarising minerals in the centre, perhaps prismatic needles of augite (probably the whole may be a large decomposed nosean or colourless hauyne). Small porphyritic flakes of mica, of an amber-yellow, or deep sherry-brown, under single nicol.

No. 52*a*, from Byrock Mountain (Pl. XXVIII, fig. 6). Remarkable fibrous mineral of rusty brown colour present. A decomposed variety of olivine (Pl. XXVIII, fig. 5). A few micro-porphyritic crystals of triclinic felspar also present. Magnetite abundant. Some of the leucite crystals contain spherical inclusions of a nearly colourless faint brownish isotropic material, which may be beads of glass. Natrolite (?) present. In some cases the olivine grains present the appearance of geniculate twinning (Pl. XXVIII, fig. 5).

No. 52*b*, from Byrock Mountain. The olivine is aggregated into clumps, and some individuals show unaltered centres, but with the fibrous decomposition penetrating them. The augite is chiefly in the form of lath-shaped micro-porphyritic crystals, many of them twinned. Some leucites have included crystals very minute, generally giving hexagonal sections and isotropic. They are mostly of a pale purplish-brown colour with a darker interior surrounded by a narrow clear exterior, and are probably nosean. Inclusions of a pale yellowish-grey prismatic augite also occur in the leucite, and long slender prisms of a colourless mineral with tranverse cracks, which is probably apatite.

No. 53, from Byrock Mountain. The olivine here shows partial decomposition, in many cases the centres of the crystals being quite fresh. Some of the leucites are arranged in aggregations either circularly around a nucleus, which consists almost entirely of a portion of the base more finely crystalline than the surrounding base, and containing a little glass (?), or in globular masses of aggregated crystals finely crystalline towards the centre and more coarsely crystalline towards the periphery, which consist wholly of leucite, and a little isotropic material, which may be glass, is present in the central portion of the aggregation.

No. 54*a*, from Byrock Mountain. This section shows perhaps better than any other what may be termed the base, consisting of minute crystals of augite, magnetite and leucite in which the micro-porphyritic minerals are imbedded. The olivines are very remarkable. They are much decomposed towards the centres, where they exhibit a fibrous structure, but towards the edges they have been altered into a translucent reddish-brown or sherry-red mineral, which has a fibrous structure more strongly marked than that of the partially decomposed portions of the olivine. They are very feebly pleochroic. This mineral, which is certainly an alteration product from the olivine, may be a ferriferous variety of melilite or possibly a ferriferous magnesian mica. The feeble pleochroism, however, of the mineral renders the former supposition the more probable. It is partially soluble in cold hydrochloric acid. Some of the micro-porphyritic augites in this slide exhibit a uralitic cleavage.

No. 54*b*, from Byrock Mountain. Similar to preceding slide. The olivines are much decomposed and converted at the edges into the deep brown mineral. Some of the individual leucite crystals enclose a nucleus of partly devitrified glassy base, the diameter of the nucleus being half the whole diameter of the crystal. In some cases these nuclei are composed of bundles of glassy beads. In other cases the glassy nuclei are surrounded by contiguous leucite crystals. Augite occurs in the form of slender prisms of a pale yellowish-grey colour in the base and also in micro-porphyritic prisms. The decomposed olivines edged with the reddish-brown decomposition mineral are frequently encircled with a fringe of primary mica. In cases the olivine is completely changed into this reddish-brown mineral, which shows a strong cleavage and is encircled by the fringe of primary yellow mica, the strong pleochroism of the latter is in marked contrast to the feeble pleochroism of the former. Glass occurs occasionally in the base in small irregular shaped pieces with dusty magnetite distributed through it.

No. 54*c*, from Byrock Mountain. Numerous micro-porphyritic crystals of olivine present, many of them remarkably fresh, without a sign of the yellowish-brown decomposition product, although they are usually cracked transversely to their longer axis. The larger fresh-looking forms have well defined more or less rectangular outlines, while those which show the fibrous brownish decomposition are irregularly oval. One triangular aggregation of the base is seen in section to consist almost entirely of minute irregular fragments of leucite and mica. Two sides of the triangular outline of this mass are defined by wavy lines of small leucite crystals. Augite is present in micro-porphyritic crystals. Another aggregation occurs, consisting almost wholly of minute crystals of olivine, with a little leucite.

No. 55, from Byrock Mountain. Slide shows general similarity to the two preceding, and contains a small undevitrified fragment of glass, about half an inch in diameter, with dusty magnetite sprinkled through it. Very remarkable instance here of a leucite crystal formed around a nucleus of fine magnetite and mica. This may be an explanation of the intercrystallized leucite and magnetite in other slides. There is also a similar arrangement of augite crystals around an included portion which is formed of the other minerals. Some augites show twinning, and sometimes the inclusions in the crystals have a somewhat zonal arrangement.

No. 56, from Byrock Mountain. Micro-porphyritic crystals of undecomposed olivine in elongated prisms with irregular edges. Augite occurs in very much elongated prisms yellowish-grey. A small cavity is observable, partly filled with minute crystals of magnetite, and enveloped by a thin coating of finely crystalline leucite. The olivine shows fibrous outlines of decomposition extending at right angles to the domes and pinacoids. Leucite shows faintly polarising lines, and in places occurs enclosed in the flakes of mica. A small amygdule (?) is observable of yellowish-grey mineral, slightly cloudy.

No. 57, from Byrock Mountain. Spherical amygdule or segregation of glassy material, or very finely crystalline leucite, with magnetite and mica encircled by a ring of leucite in partly individualized crystals. Some olivines much decomposed, others fairly clear.

No. 58, from Byrock Mountain. Two well-marked hollow (?) aggregations of leucite, enclosing a little magnetite and mica. The leucite occurs in the form of a ring, fairly thick, and is in partly individualized crystals. Very characteristic of this slide are aggregations of partly individualized crystals of leucite, arranged in a circular manner around portions of the base, sometimes composed of finely crystalline magnetite and mica, and sometimes of what appears to be partly divitrified glassy base. (Pl. XXVIII, fig. 4). One leucite crystal shows very clearly concentric lines of growth. (Pl. XXVIII, fig. 2). Minute crystals of nosean (?) occur enclosed in some of the leucites. Perhaps some elæolite or natrolite in this slide—possibly analcime. Glass inclusions in the leucite. (Pl. XXVIII, fig. 2).

No. 59*a*, from position (*a*), El Capitan. There are slight differences between this rock and the Byrock in its general microscopical characteristics. It consists of a micro-crystalline base of finely crystalline leucite, augite, and magnetic iron, with abundant macroscopic grains of undecomposed olivine, and small flakes of yellowish mica, the latter chiefly encrusting the granules of olivine. Magnetite, besides occurring in small crystals in the base, forms aggregated micro-porphyritic patches, some of which have a dendritic structure. In a small geode augite occurs in pale yellowish gray micro-porphyritic crystals, associated with olivine and magnetite, and a little leucite. In the base there is a considerable amount of cloudy interstitial material, due perhaps to the imperfect separation of the magnetite or to the decomposition of ilmenite. The aggregates of magnetite or ilmenite are surrounded by leucites in a finely crystalline state. In some of the aggregates an opaque dirty white or reddish-grey mineral occurs which is probably a decomposition product. The appearance of a cavity in the leucite aggregates seems to be due in one case here to the mechanical grinding away of the nucleus of magnetite. Fragments of crystals of triclinic felspar showing polysynthetic twinning occur very sparingly and amorphous leucite in places intercrystallized with the magnetite. Lines of flowage are noticeable in base.

No. 59*b*, from position (*a*), El Capitan. A porphyritic compound crystal of augite ⅕ of an inch in diameter, very much corroded. Porphyritic granules of olivine are abundant and very free from decomposition. (Pl. XXVIII, fig. 3.) The aggregates of iron are also macroscopic. The porphyritic grains of olivine show lines of solution (?) or basal cleavage. Base shows flowage structure.

No. 59*c*, from position (*a*), El Capitan. Remarkable oval aggregate of magnetite and leucite intercrystallised in a similar manner to the intercrystallization of quartz and felspar in pegmatite. This is suggestive of the segregative origin of the leucite aggregations. The prismatic crystals of augite in the base in their arrangement show strong lines of flowage. A few micro-porphyritic crystals of augite occur.

No. 60*a*, from position (*b*), El Capitan. Rich in macroscopic strongly pleochroic yellow mica. Secondary mineral resembling deep reddish-brown mica, or melilite pseudomorphous after olivine. Small zeolitic (?) bodies of a clear white mineral, which is partly isotropic and partly feebly anisotropic, are perhaps analcime.

No. 60*b*, from position (*b*), El Capitan. Large zeolite of a fibrous, cloudy, yellowish-grey, doubly refracting mineral, perhaps natrolite or wollastonite, surrounded by a narrow zone of a well-crystallized clear, transparent mineral almost isotropic in part. Abundant prismatic augite here in the base, which is composed of felted augite, leucite, and magnetite, all more coarsely crystalline than in the previous slides. Olivines show decidedly fibrous structure and alteration into secondary dark brown mica or melilite.

No. 60*c*, from position (*b*), El Capitan. Lines of flowage strongly marked. The chief feature in this slide is a large individual of olivine much decomposed into a yellowish-brown, somewhat opaque, brittle mineral surrounded by a zone $\frac{1}{8}$ inch thick of olivine, leucite, and augite more finely crystalline than the general rock, and characterized by the absence of magnetite. The zone merges gradually at its outer edge into the typical rock, but there is a sharp line of demarcation between its inner edge and what may be an inner narrow zone of secondary aragonite, which occurs as an alteration product having a fibrous radial structure in or around the decomposed olivine. Imperfect prisms of a mineral varying in colour from yellow, through green, into blue, is observable in association with the decomposed olivine in this inner zone, and is apparently a decomposition product, perhaps aragonite.

No. 60*d*, from position (*b*), El Capitan, consists of a micro-crystalline base of felted crystals of augite with small leucites and magnetite, with olivine tolerably abundant in slightly micro-porphyritic crystals much decomposed. Brownish-yellow mica occurs micro-porphyritically in flakes quite free from decomposition. Augite also occurs in twinned micro-porphyritic crystals the ends of which are rounded off or corroded. Oblong or oval patches of leucite (?) are observable in aggregation with the flakes of mica. Fragments of augite prisms are included in this aggregate of leucite. The ends and edges of these included augites are studded with minute granular bodies showing a tendency to a fibrous radial arrangement, and perhaps of the same composition as the augite. The phenomenon may be due to the partial dissolving of the augite prisms and the recrystallization of the dissolved mineral upon the augite. In the neighbourhood of these aggregates are crystals resembling garnets in colour. Examined, however, under the highest power, they are seen to be composite bodies composed of a clear white mineral incrusted by somewhat opaque brownish granular matter, similar to that noticed on the augite prisms. These may therefore be leucites coated with granular augitic (?) matter.

No. 60*e*, from position (*b*), El Capitan. In this section the base is somewhat similar to that in the preceding one, but enclosed in it is an oval macroscopic body composed of a yellowish-grey, somewhat opaque mineral enclosing isolated portions of the base. This body is about ½ inch long, by ⅓ inch wide, and the mineral of which it is composed shows a decidedly parallel fibrous structure in places, and under-crossed nicols allows only a little light to pass, which shows that it is made up of small mosaics similar to those observable in amygdaloidal minerals. Before the blow-pipo the mineral reacts strongly for soda and fuses to a clear glass without intumescence. Hardness between 5 and 6. It is regularly attacked by hydrochlorid acid. It is therefore a silicate of soda, &c., and as it is of secondary origin, as proved by its mosaic structure it is probably analcime. The fact, however, of portions of the base having been included in it renders it improbable that the whole body is an ordinary amygdaloid. It seems more probable that it is a large pseudomorph after some soda-bearing silicate such as nosean. It is certainly to be referred to the same mineral as was observed in Slide 50*b*, which is nearly isotropic and shows well marked cleavages, as already described. It is just possible, however, that this soda silicate may be pseudomorphous after olivine.

No. 61*a*, from position (*d*), El Capitan, consists of a micro-crystalline base of felted augite, leucite and magnetite, with micro-porphyritic olivine crystals very free from decomposition, micro-porphyritic flakes of yellow mica and one large microscopic augite very much corroded. The leucites are characterized by circularly arranged inclusions of glassy beads.

No. 61*b*, from position (*d*), El Capitan. The base is similar to the preceding, but contains secondary growths of fibrous aragonite in places. This slide is very rich in leucite and contains an oval aggregate of decomposed leucite and interstitial aragonite. Most of the decomposed leucite in this aggregate shows the distinct outlines of the original crystals and the characteristic zonal inclusions, but is of a yellowish-grey colour, a trifle opaque, and somewhat resembles the large opaque bodies which occur in Slides 60*e*, and 50*b*, and which it was suggested might possibly be decomposed nosean.

No. 62*a*, from position (*c*), El Capitan. Macroscopically this section presents a somewhat brecciated appearance, which however, on microscopical examination is found to be due more to the presence of irregular aggregations and the non-uniform distribution of the magnetite, than to a true fragmental structure of the rock, although there are a few bodies present which may have been introduced prior to its thorough crystallization. The slide is characterized by the presence of abundant micro-porphyritic crystals of olivine, whose outlines are much corroded, and which are imbedded in a finely crystalline base, consisting of minute crystals of augite, leucite, magnetite and mica. The olivines are as a rule fresh, but show distinct serpentinisation along the cracks and often around the outlines, the product being a bluish-green clear mineral, which is isotropic. The whole rock is very much more finely crystalline and more compact than any of those previously described. The bodies which may have been introduced subsequent to the eruption, but previous to the final consolidation of the lava present an irregular outline and are generally slightly elongated and angular. They consist of a blackish nearly opaque and somewhat streaky base of very fine magnetite and probably glassy material enclosing small irregular crystals of leucite. Fragments of more coarsely crystalline leucites occur in the finely crystalline base, but viewed under the microscope, the edges of these fragments merge gradually into the more finely crystalline base, so as to give them the appearance of being comparatively coarsely crystalline aggregates. Probably both the fragments, which have the appearance of having been introduced subsequent to the eruption of the lava and the more coarsely crystalline aggregates, which form an essential part of the base, have been formed from the partially cooled and solidified portions of the lava, derived probably from its upper or under surface, which has become broken up from time to time by the movements of the lava-stream, and entangled in the magma at its under surface. It is also possible that some of these fragments may have been originally lapilli, although their irregular outline and restricted occurrence (these fragments being found only in the under part of the lava-sheet within a few feet of its lower surface) are rather opposed to this theory. The specimens, from which these slides were prepared, were taken from within a few feet of the under surface of the lava-sheet at El Capitan. Had these tuffs been derived from a point of eruption, beds of them would probably be observable interstratified with the lava-sheet, and such have not yet been observed. The surface also of the lava-flow would probably in that case have partaken of a tuffaceous nature which it does not.

No. 62*b*, from position (*c*), El Capitan. This slide closely resembles the last in general appearance and microscopical characters, except that here the fragmental appearance is not so well marked.

No. 62*c*, from position (*c*), El Capitan. Generally similar in structure to the last two—showing two kinds of fragments, and one variety of aggregate.

No. 63*a*, from position (*e*), El Capitan. This slide presents a much more brecciated appearance than those last described. Many of the fragments have a distinctly defined outline, and most of them are darker from the greater abundance of magnetite, than the rest of the rock. The whole section contains a large number of micro-porphyritic much decomposed olivines. These occur scattered through the rock, and are of frequent occurrence in many of the fragments, which also contain recognizable leucites, thus showing indisputably that some of these are really fragments of the earlier consolidated portions of the lava, which have been broken up by the movements of the flow. Numbers of the fragments however, do not contain microporphyritic olivines nor recognizable leucites, but generally show an indistinctly laminated structure. These are undoubtedly foreign fragments, probably small pieces of the slate rock over which the lava flowed, and which were picked up by it. A few fragments of elongated shape, irregular outlines, and extinguishing completely under crossed nicols are probably glass. These are opaque towards the centre and clear at the edges. The longer axes of these fragments generally lie approximately parallel to one another, and probably "end on" to the current of the lava-stream. They are imbedded in a tolerably clear base containing numerous small flakes of mica, and prisms of augite, and dotted with minute magnetite crystals. This base under crossed nicols is seen to be largely composed of doubly refracting minerals.

No. 63*b*, from position (*e*), El Capitan. Besides having a brecciated appearance, this section shows abundant amygdaloids. Fragments are observable, both of leucite basalt and of slate (?), in a base consisting of magnetite, augite, and leucite; the first mineral being by far the most abundant, and in which are imbedded micro-porphyritic crystals of much decomposed olivine and flakes of mica. The amygdaloidal cavities are generally small but very numerous. They are of two kinds, the first irregular shaped, and the second having a circular or roughly hexagonal outline. Both are partially or wholly filled with a turbid grey mineral, with a faint reddish tinge. In cavities of the first kind the mineral has a strongly marked fibrous structure, the fibres having their longer axes at right angles to the sides of the cavity. In amygdaloids of the second kind, the mineral appears to be pseudomorphous after leucite, and has probably resulted from the decomposition of that mineral. In both kinds the mineral is probably analcime.

No. 63*c*, from position (*e*), El Capitan. This section presents macroscopically a minutely brecciated appearance. (Pl. XXVIII, fig. 1.) The majority of the fragments are seen microscopically to be undoubtedly pieces of the leucite basalt, showing individually great differences in constitution. Some consist almost entirely of magnetite, with a few crystals of leucite, and others have the general character of the typical rock. The whole section is very dark, almost opaque, from the enormous quantity of magnetite present, but the fragments are, as a rule, the darkest. Scattered indiscriminately through the section, in most of the fragments as well as in the general base, are large micro-porphyritic crystals of decomposed olivine, showing the usual fibrous decomposition. Some fragments are present which show an indistinctly laminated appearance, and these are probably pieces of slate which have been caught up by the lava as it flowed over the surface. It is also probable that there is a considerable amount of glassy material in the base, which consists chiefly of leucite, augite, magnetite, and minute fragments of mica, and from the great abundance of magnetite it has quite a granular appearance.

VII.—Comparison with other Leucite-bearing Rocks.

There is a very marked similarity between the Byrock and El Capitan rocks, both macroscopically and microscopically. Some slight differences exist between them, which do not, however, weigh much against the probability of their having formed portions of the same eruption. The El Capitan rock is somewhat lighter coloured, but in part more decomposed, not so uniformly compact, and has the porphyritic minerals olivine and mica better developed than is the case in the Byrock rock. The rocks are otherwise identical both in chemical composition and mineralogical constitution. So far there is little evidence as to the direction in which the lava flowed, for no traces of a crater or other point of eruption have yet been met with in any part of the district. In general appearance the Australian leucite basalt resembles very much the leucitite of the Capo di Bove, near Rome. In microscopical structure it differs somewhat from it, chiefly in the abundance of its olivine and mica, and the absence of primary melilite and nepheline. In the comparative abundance and distribution of the leucite, augite, and magnetite, the two rocks are very much alike. The chemical analyses of the Byrock and El Capitan leucites, combined with approximate estimates made from drawings from the microscopical sections of the rock, show that the Australian leucite basalts contain nearly the same proportion of leucite as the Vesuvian lavas, erupted between 1631 and 1868, described by Haughton and Hull (*loc. cit.*), the percentage of leucite in the latter ranging from 33·6 to 44·9 per cent., calculated on the hypothesis of a minimum amount of paste. The minimum proportion of leucite in the Australian lencite basalts is 25 per cent., and it probably amounts to about 30 per cent. in places.

VIII.—Age.

The evidences as to the age of the eruption of this lava are not so far of a conclusive character. The question whether these widely separated outliers of basalt originally formed portions of one lava-flow remains yet unsettled, although from their similarity of composition and microscopic structure, it is probable that they did so.

That they may be of Palæozoic age is unlikly from the comparatively small amount of decomposition which the component minerals of the rock have undergone, although from their stratigraphical position they may have existed as outliers since Palæozoic times, like the neighbouring horizontally-bedded Devonian outliers which rest unconformably on the upturned edges of the Silurian slates, and form

Mount Oxley. The leucite basalts could not, however, have been older than the Devonian, for pebbles of Silurian quartzite occur in the basalt at Byrock Mountain.

During Secondary times this part of the country must have been more or less under water, and it is evident, from the general character of the leucite rock, and the occurrence of water-worn river-drift underneath it, that the lava must have originally flowed out over dry land. There is every reason for believing that, during the earlier part of the Secondary Period when the Lower Cretaceous formation was being deposited over the central part of the continent, this district, situated near the edge of the Cretaceous sea was, if not wholly under water, at any rate in the condition of an archipelago. It is even probable that during the deposition of the Upper Cretaceous, or Desert Sandstone, this district was still locally submerged, and if the lava had been erupted during Secondary times when such physical conditions obtained, some portions at least of the basalt would undoubtedly present subaqueous characters. This is, however, not the case except locally, where the scoriaceous character of the rock is quite satisfactorily explained by the fact that at such points the lava flowed into the waters of the creek, which existed in the bed of the valley down which the lava flowed.

So far as we know, there is no stratigraphical evidence to show that the rock had a Post-Secondary origin, although it is not unlikely that such was the case, and that it was erupted in early Tertiary (?) times, like the Eocene basalts of New England in this Colony. The point of eruption of this lava was probably no exception to the general rule, in being situated near the sea. In the Byrock and El Capitan districts the latest known marine formation is of Cretaceous age. It is possible, however, that in these districts outliers may yet be found of the marine Miocene formation, which occupies so large an area of the south-west of the Colony. The date of the eruption of the leucite basalt, therefore, probably lies somewhere between the Lower Cretaceous and the Miocene periods. Of all the various outliers in the two localities none of them, so far as were examined, rested upon the Cretaceous formation. Their nearest points, some forty miles apart, are separated by a stretch of level country from which rise high isolated hills formed of Silurian quartzite, the denuded peaks of Pre-Secondary mountains, but, so far as it has been traversed and examined, with no outliers of leucite basalt.

There is abundant evidence to prove that the degradation which this country has undergone since early Tertiary times has been very great and it is not improbable that those portions of the flow between El Capitan and Byrock Mountain may have been completely denuded; because most of the level country between those two points consists of the more or less soft beds of the Cretaceo-Tertiary formations, and if the lava had covered these in a continuous flow it would have been far more liable to be denuded off such easily eroded strata than from a position where it rested on the hard Silurian slates or granite, for, as already stated, such portions of it which still exist rest, in the one case on Silurian slate and in the other on granite, so that in those positions its denudation would not be assisted by the fact that the underlying rocks were soft and therefore easily worn away. There is, however, a tract of country between Coronga Peak and the Western Railway, which has not yet been thoroughly examined, so that it is just possible that other outliers of the rock may yet be discovered which will perhaps show a probable continuity between these two places. If these numerous outliers are the remnants of a single lava-flow, it is impossible that its eruption could have taken place within recent times, because of the enormous denudation they have undergone. If this fact be taken into account together with the comparatively small amount of decomposition which the individual minerals have undergone, and the absence from this district of marine conditions, which are usually a necessary element in the volcanic eruptions, during, at the latest Post-Miocene times, it seems very likely that its eruption took place during Cretaceous or Tertiary times, and when the various outliers have been more thoroughly examined this may possibly be proved, by stratigraphical evidence especially by the discovery of plant remains in the river drifts under the basalt, similar to those found in the pipeclays and lignites of the Tertiary "deep leads" of the Cordillera of New South Wales.

XVIII.—Our Present Knowledge of the Palæontology of New Guinea: by R. ETHERIDGE, Junr., Palæontologist.

[Plate XXIX.]

SO LITTLE is at present known of the Palæontology of New Guinea that it may perhaps be well to pass in review the different, although brief papers, relating to the subject, and to add what little information can be gathered from more recently made collections.

So far as I am aware, no fossils of Palæozoic, and only those of Mesozoic age to the least possible extent have been noticed from New Guinea, and the existence of fossiliferous Tertiary rocks was, I believe, first announced by Mr. C S. Wilkinson, who based his determination on a small series of specimens obtained at Yule Island, during the progress of the " Chevert" Expedition, under Sir W. Macleay. During this exploration were obtained, amongst other rocks :—

(1.) Oolitic limestone of Tertiary age from Bramble Bay.

(2.) Yellow calcareous clay, from the Katau River.

(2.) Yellow and blue calcareous clays, from Yule Island, and Hall's Sound.

The clays from the last named localities were believed by Mr. Wilkinson, "as indicated by the fossils contained in them, to belong to the Lower Miocene Tertiary period,[*]" and to be similar to like beds at Geelong, and Cape Otway, in Victoria.

From Hall's Sound, Mr. Wilkinson determined *Voluta macroptera,* M'Coy, *V. anticingulata,* M'Coy, and a number of other shells only named generically, and therefore of little use from any but a general stratigraphical point of view. The Katau and Bramble deposits were believed to be of the same age. The Yule Island rock is wholly composed of corals, shells, and echini, forming a "concrete of fossils." This paper was followed by two from the pen of the Rev. J. E. T. Woods,[†] entitled "On a Tertiary Formation at New Guinea[‡]," and "On some Tertiary Fossils from New Guinea"[§]. Both these memoirs deal with the same fossiliferous deposit at Yule Island, which Mr. Wilkinson had before him. They are evidently intended as a refutation of the conclusions arrived at by the latter; but strange to say, no mention whatever is made of Mr. Wilkinson having previously occupied himself with the subject. The first paper contains a description of an Echinid, *Temnechinus Macleayana,* Ten.-Woods, and records as fossil the occurrence of a known living species, viz., *Peronella decagonalis,* Lesson. *Temnechinus* is a European and Indian Tertiary genus, and lives still, although, as Mr. Woods says, is chiefly indicative of a Pliocene age. *Peronella decagonalis* is a recent species, met with in eastern seas. The conclusion arrived at by the author is that the deposits yielding the fossils in question, are not as old as the Murray River, Mount Gambier, or Cape Otway Tertiaries, but he regards them as Lower Pliocene.

In the second paper, two shells are described, *Pecten novæguineæ,* and *Dolium costatum.* These are held to confirm the previously expressed views, and Mr. Woods was of opinion that none of the New Guinea fossils were identical with those of Southern Australia. No mention whatever is made of the two univalves, *Voluta macroptera,* and *V. anticingulata,* specially referred to by Mr. Wilkinson.

So far as I have been able to gather, the first reference to fossils of Secondary age from New Guinea occurs in Mr. C. S. Wilkinson's Annual Report on the Geological Survey of N. S. Wales for 1877[‖], wherein he states that the collection of M. d'Albertis contained Ammonites. In an anonymous article in the Sydney *Daily Telegraph*[¶], Mr. Wilkinson is credited with assigning these Ammonites to the Upper Oolite or Lower Cretaceous. It is thus quite clear that about this time Secondary rocks had been recognized, support being given to this by some remarks made by Professor F. W. Hutton, in his excellent essay on the "Origin of the Fauna and Flora of New Zealand"[*]. Therein he says :—"Of the geology of New Guinea it is known that Jurassic rocks are largely developed both in the north and in the south . . . . . no Cretaceous rocks are known from any part."

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[*] Proc. Linn. Soc., N. S. Wales, 1876, I, pt. 2, p. 113.

[†] Since these remarks were written Natural History has lost one of its most devoted followers by the death of the Very Rev. J. E. Tenison-Woods, which lately took place after long and painful suffering.

[‡] *Ibid,* 1877, ii, pt. 2, p. 125.

[§] *Ibid,* pt. 3, p. 267.

[‖] Ann. Report, Dept. Mines, N. S. Wales, for 1877, [1878], p. 193.

[¶] Jan. 5th, 1886.

The next publication bearing on the Palæontology of New Guinea was a paper by the late M. de Miklouho-Maclay,[†] who described a large part of the coast thereabouts as nothing more than uplifted coral-reefs, but from a greenish sandy clay, forming the nearest hills to the coast-line at the village of Bongu, from 100 to 400 feet high, he collected thirty-eight species of mollusca. From the determinations of Mr. J. Brazier,[‡] who examined the collection, it is manifest that this deposit can only be regarded as of Post-Tertiary age. The species are identical with those now living in Torres Straits, the China sea, and around the Philippine Islands. The following is a list of those specifically determinable taken from Mr. Brazier's paper :—

Ranella albivaricosa, *Reeve.*
Nassa siquijarensis, *A. Adams.*
Oliva neostina, *Duclos.*
„ lepida, *Duclos.*
„ ispidula, *Linn.*
Terebra staminea, *Gray.*
Dendroconus glaucus, *Linn.*
Strombus canarium, *Linn.*
Bulla ampulla, *Linn.*
Atys cylindrica, *A. Adams.*
Dentalium longitrorsum, *Reeve.*
Corbula crassa, *Hinds.*
Corbula albuginosa, *Hinds.*
Tollinella M'Andrewi, *Sby.*
Arcopagia pinguis, *Hanley.*
Phylloda foliacea, *Linn.*
Tellinides conspicua, *Hanley.*
Peronæa scalpellum, *Hanley.*
Metis spectabilis, *Hanley.*
Chione calophylla, *Hanley.*
„ imbricata, *Sby.*
Dione bullata, *Sby.*
Leda pullata, *Hinds.*

To within a few months ago this included all that was known to the writer of the Palæontology of New Guinea. Both the Germans and Dutch[§] may have obtained collections from their respective portions of the island; but, if such is the case, the descriptions have not come under notice.

During the comparatively recent expedition to New Guinea in 1885, fitted out by the Royal Geographical Society of Australasia,[‖] a few fossils were obtained which next claim our attention. From the head of the Strickland River an olive-green mudstone was obtained, full of comminuted marine fossils, chiefly mollusca. The lithological character of the matrix points to a volcanic origin. None of the species were nameable.

From the first foot-hills of the Upper Strickland River a block of fine sandstone, containing *Pecten*, was obtained. This, Mr. A. J. Vogan, who was attached to the expedition, informed me was *in situ.* The shells are too much worn by weathering to attempt a specific determination, but they seem to have more of a Tertiary than a Secondary aspect.

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[*] Presidential Address to the Philosophical Institute of Canterbury, N. Z., Nov. 1st, 1883.

[†] Volcanic Activity on the Islands near the north-east coast of New Guinea, &c. *Proc. Linn. Soc. N. S. Wales*, 1885, ix., pt. 4, p. 963.

[‡] *Ibid*, p. 988.

[§] Prof. K. Martin, of Leiden University, has published a paper entitled "Eine Tertiarformation von Neu-Guinea und benachbarten Inseln" (*Samml. Geol. Reichs-Mus. Leiden*, 1881, I., pp. 65–83, t. 3), in which a Tertiary species of *Alveolina* is described. A general geological summary regarding New Guinea is also given.

[‖] Special Record of the Arrangements for the Exploration of New Guinea. *Proc. Geograph. Soc., Australasia Special vol.*, 1885, p. 157.

At Observatory Bend, Strickland River, numerous travelled nodules and small boulders were collected, revealing a totally different kind of life, chiefly the remains of Ammonites. But amongst them is a bivalve, either an *Aucella* or an *Inoceramus.* If the latter, it is decidedly of the type of the Cretaceous, *I. concentricus.* Unfortunately the characters of the hinge cannot be ascertained. These fossils are, however, of little importance when compared with the Ammonites. Out of a number of nodules, in which the fossils are indicated by impressions of casts, a fairly representative series has been selected, containing four more or less recognizable species, or at any rate species which can be referred to one or other of the sections into which the old genus *Ammonites* is now broken up, and the facies of which is sufficiently clear for broad generalization.

The section *Stephanoceras* is largely represented by an Ammonite of the group of *A. calloviensis,* Sby. (Pl. XXIX, fig. 5), and even closely allied to that species. At first sight the primary costæ springing from the umbilical margin are not very apparent in our specimens, but attentive examination reveals them as in D'Orbigny's figure[*] of this species, but closer together, and therefore more numerous. It would also appear that the umbilicus is smaller than in the European form, and less telescopic, wherein these shells approach *Stephanoceras transiens,* Waagen,[†] from Kutch, or *S. maya,* J. de C. Sby.[‡] They possess the same form and arrangement of ribs as in the latter, which commence quite simple at the umbilicus, and break up at about equal distances into bundles of three, whilst the shell is rather more compressed.

The next species partakes of the form of *Stephanoceras Blagdeni,* J. Sby. (Pl. XXIX, fig. 2), or equally well with *S. coronatus,* Brug. It is a small shell, with the costæ of the back and the tubercles less marked than in the above species. On the other hand the cross-section of the whorls clearly indicates its relation to this group. The specimen also partakes, in some degree, of the features of the shell figured by D'Orbigny as *Ammonites Humphresianus,*[§] but the umbilicus in the former is deeper. A comparison may also be made with Quenstedt's figure of *S. coronatus.*[||]

Two rather well marked Ammonites (Pl. XXIX, figs. 1 and 3) appertain to the group of *Stephanoceras lamellosum,* J. de C. Sowerby,[¶] but as compared with that species, possess a wider and more open umbilicus, with the costæ of the back less upwardly curved and more horizontal; in fact the costæ are all more direct and lack the sigmoidal curve on the flanks of *S. lamellosus*. From *S. Grantianum*, Oppel, as figured by Waagen, the costæ seem to be finer, but to J. de C. Sowerby's figure of this species, under the name of *A. Herveyi*,* our fossils bear a close resemblance, and also to D'Orbigny's figure† of the same, in the breadth and nature of the back. An affinity is also to be detected with the same author's *Ammonites macrocephalus*,‡ but not with that of Waagen, under the same name. A third fragment, however, possesses costæ quite as coarse as those shown in the latter's illustration of *Stephanoceras Grantianum*.

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[*] Pal. Franç. Terr. Jur., Ceph. I. Atlas, t. 162, f. 10.
[†] Pal. Indica, Jurassic Fauna of Kutch, I. Ceph. t. 32, f. 2a.
[‡] Trans. Geol. Soc., V (2) t. 61, f. 8.
[§] Pal. Franç. Ter. Jur., Ceph. I. Atlas, t. 134.
[||] Cephalopoden, 1849, Atlas t. 14, f. 4a.
[¶] Trans. Geol. Soc., V (2) t. 23, f. 8.

Yet another Ammonite (Pl. XXIX, fig. 4), which Dr. H. Woodward, who was kind enough to examine casts of all these fossils sent to him by myself,—compares to *A. lingulatus*, Quenst., of the White Jura. Figures of this species are not accessible to me, and I cannot find anything precisely like it, although it seems to be of the Upper Oolite type of *A. Lamberti*, Sby., and *A. Sutherlandiæ*, Sby., as figured by D'Orbigny,§ in so far as the break in the double costation goes, but the back of our shell is much too broad, and the costæ too fine. The square back, with its oblique costæ, and the marginal crenulations, all convey to this shell a much more Upper Oolite or Lower Cretaceous aspect than they give to it a Lower Oolite facies. Neither is it impossible that a relation may exist between it and *A. Leai*, Forbes.‖

So far as our present knowledge of Queensland Ammonites exists there is no connection between the latter and either of the species described above, although our Pl. XXIX, figs. 1 and 3, bear some resemblance to Moore's *Ammonites macrocephalus*¶ from Western Australia.

The only other organic remains so far brought from New Guinea, were obtained by Mr. Theodore Bevan during his fifth and last exploring expedition along the south coast of the island in 1888.** These consisted of a few shells from the Aird Hills, Douglas River, and were determined by Mr. J. Brazier, and the writer. They were obtained from an earthy-mould, or silty-mud, and cannot be geologically of any great age, but are of considerable interest from the position of the deposit containing them. This is described by Mr. Bevan in the following words:—"The term Aird Hills describes an island of probably moderately recent upheaval, on which a cluster of volcanic cones, some ten in number, and covering an area of about five square miles, are surrounded by deep navigable channels of fresh water . . . The general formation of these trachyte hills is a volcanic tuff. The summit of this particular cone, however, is covered with a deposit of semi-fossilized fluviatile shells contained in an earthy mould or silty-mud." The species determined were the following:—

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* Trans. Geol. Soc., V (2) t. 23, f. 5.
† Pal. Franç. Ter. Jur. Ceph I. Atlas t. 150.
‡ Pal. Franç. Ter. Jur. Ceph. I. Atlas, t. 151.
§ Pal. Franç. Terr. Jur. Ceph. I., Atlas, t. 177.
‖ Quart. Journ. Geol. Soc. I. p. 178, t. 12, *a* and *b*.
¶ *Ibid*, xxvi. t. 15, f. 5.
** Mr. Theodore F. Bevan's fifth expedition to British New Guinea, 1888, p. 21 (8vo. Sydney, Government Printer).

Melania clavus, Lamarck.—This species is represented by several examples. It is found in the living state at New Ireland and at the Philippines; it was also obtained by Mr. John Brazier, in the Solomon Islands.

Neritina gagates, Lamarck,—comprises more than two-thirds the entire collection, and is present in several varieties. It is a characteristic New Guinea species, and was found by Mr. Brazier in the Katau River.

Cyrena sp.—Several valves, which cannot exactly be referred to any known species from New Guinea. They approach nearest to *Cyrena nitida*, Deshayes, from Borneo, and are, perhaps, only a variety of it.

The collection of the Queensland Geological Survey has been enriched by the presentation by Mr. E. Edelfelt of specimens of brown or yellow marl from Maiva Village, found at a height of about two hundred feet above sea level. The marl has plentifully scattered through it the remains of small shells in the form of internal casts, and a few fragmentary corals. By the kind permission of my co-writer, Mr. R. L. Jack, the following extract from our forthcoming work on the "Geology and Palæontology of Queensland," may be appropriately inserted here:—

> The most striking of the corals is a species of *Alveopora*, allied to those described by Dr. A. E. Reuss, from the Tertiary beds of the Tiji-Lanang Valley, Rongga District, Java.[*] The trabecular septa are strong and spine-like, much curved, and six, or perhaps more, in a cycle. They have this peculiarity, that they appear to be developed in pairs, a character to some extent seen in Reuss' specimens, but in the present fossils carried to a much higher degree. The spurious columella formed by the union of the septa is of the slightest construction. In the character of the septa this coral appears to be most nearly allied to *Alveopora brevispina*, Reuss,[†] but in other features to *A. hystrix*, Reuss.[‡] If the paired condition of the septa, here so very marked, is a constant and definite character, and it appears to be so, it will at once distinguish this coral from all those described by Dr. Reuss.
>
> The largest and best preserved coral is a species of *Leptoria*, a genus not met with either by Reuss, amongst the Javan corals, nor by Professor K. von Fritsch,[||] amongst those collected in Borneo by Mr. R. D. M. Verbeek. On the other hand Professor K. Martin, of Leyden,[§] describes an allied genus *Cœloria*, from the former country. The characters of the New Guinea *Leptoria*, as portrayed in the single specimen are not sufficiently clear for specific description, and make one long for further materials. *Leptoria* is extensively distributed in the Indian and Pacific Oceans.
>
> Next in order is a well-marked *Galaxea*, again only a fragment, but clearly not far removed from the recent *G. clavus*. The corallum, as preserved, is split in half longitudinally, and exhibits several corallites radiating outwards, surrounded by a copious peritheca.

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[*] Uber fossile Korallen von der Insel Java. *Reise Osterr. Fregatte "Novarra,"* 1851-59. *Geol. Theil*, II *Band*, 2 *Abth.*, p. 165.

[†] *Loc. cit.*, t. 8, f. 7, *a–c*.

[‡] *Ibid*, t. 8, f. 8, *a–c*

[||] Fossile Korallen der Nummulitenschichten von Borneo. *Palaeontographica*, 1878, *Suppl. Band* III., *lief.* 1, *heft* 3, p. 93.

[§] Die Tertiärschichten auf Java, 2 Theil, p. 137 (folio, Leiden, 1880.)

The last to be noted, but certainly not the least important, are two examples, fragmentary unfortunately, of the interesting genus *Deltocyathus*, distinct both from the Tertiary and recent species *D. italicus*, Ed. and H., and the recent *D. magnificus*, Moseley. The occurrence of this genus in these New Guinea beds is of the highest interest, following as it does upon its discovery by the "Challenger" Expedition in the Pacific.[*]

The material presented by Mr. Edelfeldt to the Queensland Survey Collection is of too limited a nature to permit any definite statement to be made as to the age of the beds, but they are either younger Miocene or Pliocene, probably the latter. The Javan series described by both Reuss and himself are considered by Professor K. Martin to be of Miocene age."[†]

Such is a brief outline of the Palæontology of New Guinea, so far as it is known to the writer. Briefly reviewing these facts, it is manifest that the oldest fossiliferous rocks on this island-continent, of which we at present have any record, probably correspond homotaxically with the Upper Oolites of other countries, more particularly the European, at the same time displaying some relation to the Indian beds of the same age. As regards the *Inoceramus* it would appear to resemble an old-world Cretaceous species; but the specimen being a single one too much stress must not be laid upon this point. It may simply be said that Cretaceous rocks put in a claim for consideration.

Of the Tertiary fossils it is necessary to speak more fully, but with caution. The presence of *Voluta macroptera* and *V. anticingulata* in the Yule Island deposit, would go a long way towards correlating the latter with the beds containing these shells at Schnapper Point and Muddy Creek, in Victoria, as suggested by Mr. C. S. Wilkinson. I am indebted to the kindness of Prof. W. T. Stephens, M.A., for an opportunity of examining the Yule Island collection in the Macleay Museum, [‡] but the species mentioned were not observed there, and only those described by the Rev. Mr. Woods came under observation. An attentive examination of these rather leads me to accept Mr. Woods' suggestions as to the age of the fossils in question. The matrix is also clearly the same as that containing the corals collected by Mr. Edelfelt at Maiva Village. [§]

The urchin described as *Temnechinus* does not appear to belong to that genus as defined by its originator, Edward Forbes, [‖] and at the present moment I am not prepared to generically place the specimen. It may probably be an undescribed form.

The *Peronella* would appear to be a small individual of the characteristic and generally distributed Australian species, to which Mr. Woods has referred it. The specimen of *Dolium costatum*, although only an internal cast, is one of so strongly and distinctly marked a species as to be readily recognizable from the other Australasian forms. The simple and distant costæ and canaliculate suture distinguish it at once. The *Pecten novæ-guinæ* is not identical, says Mr. Brazier, with any existing species in neighbouring waters, and must therefore be regarded, with the so-called *Temnechinus*, as peculiar to the Yule Island deposit. It is, however, remarkably like a South American *Pecten*, described by D'Orbigny from the Tertiary rocks of Patagonia, as *P. paranensis*. * In addition to the species just mentioned, I detected in one of the blocks of the Macleay collection the internal cast of a *Strombus*, which Mr. Brazier regards as that of *S.* (*Gallinula*) *Campbelli*, Gray, a species now living in the Australian seas.

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[*] "Report on certain Hydroid, Alcyonarian and Madreporarian Corals," &c., by Prof. Moseley—*Voy.* "*Challenger.*" *Zoology*, *vol.* II., 1881, p.p. 147 and 148.

[†] *Loc. cit.*, 2 Theil, p. 38.

[‡] The fossils were collected by Mr. Brazier.

[§] Specimens are in the Mining and Geological Museum, as well as in the Queensland Survey collection.

[‖] Mon. Echinodermata Brit. Tertiaries, 1852, p. 5. The New Guinea fossil does not possess the typical excavations along the sutural margins of the plates seen in all true forms of *Temnechinus*, nor are the ambulacral plates confluent. These characters are emphasized by Forbes, and accepted by A. Agassiz in his Revision.

XIX.—On the Mineral Spring at Rock Flat Creek, near Cooma, Monara District: by WILLIAM ANDERSON, Geological Surveyor.

[Plate XXX.]

THIS spring is situated about ten miles to the south-east of Cooma, and occurs in close proximity to the western bank of Rock Flat Creek, in the Parish of Dangelong, County of Beresford.

Since the early days of the settlement of this part of the Colony, it has been known as the "Soda-water Spring," and used to be a favourite camping ground for teamsters and travellers, who were attracted thereto by the reputed quality of the water. It has been largely used by the people living in its immediate neighbourhood, and the spring has at the present time become a favourite resort by the inhabitants of the district.

From report it would seem that years ago its volume was much greater than it is at present. This may, to a certain extent, be due to the long continued droughts, which have been of late years so prevalent in this Colony. Though such droughts can hardly affect the supply of water from a deep-seated spring to such an extent as they would that from a more superficial one, yet they must have a secondary effect in lessening the amount of water that finds its way to the surface, for the want of surface soakage allows of the superficial strata becoming more or less dessicated, and this necessitates a wider soakage of the spring-water among the strata through which it rises during its passage from a deep-seated origin to the surface, and consequently the amount which reaches the surface must be appreciably diminished.

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* See Darwin's Geol. Obs. Volc. Islands and Pts. of S. America, Voy. "Beagle," 2nd. Edit., 1876, t. 3, f. 30. In *P. paranensis* each costa, as in the New Guinea species, is divided into three or four ribs. The concentric laminæ in the latter are continuous over the costæ and intervening valleys, forming frills, but in the former the ribs of the costæ are separately decorated by concentric lines of projecting tooth-like spines. The interior ear also in the South American form is more deeply divided than in our species, and the posterior is less granulate.

Large areas of the Cooma district are covered superficially with Tertiary basalt, which locally overlies pipeclays and river drifts. Generally these newer rocks rest on the Siluro-Devonian slates, with granite and other eruptive rocks intruded among them. Between Cooma and the spring at Rock Flat Creek, the country consists of Tertiary basalt, the whole thickness of which has been completely eroded in the vicinity of the creek, the Siluro-Devonian slates below it being thereby exposed at intervals in the bottom of the valley. In the neighbourhood of the spring the basalt terminates some distance to the east of the creek by abutting against the Siluro-Devonian hills, which still rise to a considerable height above its level, thus indicating that the country immediately to the east of the creek must have been at the time of the eruption of these Tertiary lavas high ground, formed of Palæozoic rocks. The valley which has been eroded by the creek is wide, open, and of considerable depth. In its neighbourhood and on the basaltic country generally there is little or no timber, the only positions in which a few dwarfed trees grow being on the outcrops of the Palæozoic rocks. In the bottom of the valley there are two outcrops of Siluro-Devonian quartzite, one close to the spring, and the other some distance up its western slope. On this latter outcrop although consisting merely of a mass of quartzite blocks with little or no soil among them, a few stunted trees grow. The trend of these quartzite outcrops shows the general strike of the Palæozoic rocks to be nearly north and south.

The spring rises in close relation to the western edge of the most easterly quartzite outcrop, but so little of the older Palæozoic rocks have been exposed that it cannot be visibly demonstrated that a fault exists along the line from which the waters emanate. It is however certain that it is in no way connected with the Tertiary lavas, that is to say that the spring is not a drainage coming from below the basalt, but it has probably a deep seated origin. From the occurrence of the two parallel outcrops of similar quartzite, and the presence of the spring in connection with one of them it is reasonable to infer, that they have been originally portions of the same bed and have become separated by the intervention of a fault, and that the deep seated waters have found their way to the surface by means of it. The faulting of the Palæozoic rocks is certainly much older than the eruption of the Tertiary basalt, but it is not probable that the waters of the spring came to the surface before the Tertiary lavas covered it, for there is no evidence of the existence of any previously formed calcareous tufa below the basalt, where a section can be seen in the neighbourhood of the spring, and all the calcareous accumulation now visible has certainly been deposited since the erosion of the valley, which has taken place since late Tertiary times.

The geology of the immediate vicinity of the spring is shown on Pl. XXX. In this locality the creek has cut through the Tertiary basalt and for a short distance into the Siluro-Devonian bed-rock which is exposed on the eastern bank, as a series of small quartzite ridges. The banks of the creek are formed of Pleistocene and recent alluvial flats of variable lateral extent. Between the quartzite ridges and the creek there is a superficial deposit consisting chiefly of carbonate of lime, which has been deposited by the overflow waters from the spring as they found their way towards the creek. This deposit occupies an area of about five acres, and at its northern end the waters of the creek have cut a passage through it, leaving on the western bank a small outlier of the deposit. Little or none of this calcareous tufa exists on the eastern side of this quartzite outcrop. The surface of the deposit is very uniform in appearance, that is to say, there is no well-marked arrangement of the superficial layers, simulating terraces, &c., which are often an accompaniment of such precipitations, although the northern end of the deposit, when viewed from a little distance, presents a faintly terraced appearance, which is, however, by no means marked.

The waters have, at various periods, flowed out at the surface by different openings, along the western edge of the more easterly quartzite outcrop. The position of these openings has changed progressively from south to north, the direction of the fall of the creek, the older ones having been at the southern end of the calcareous deposit, the chief opening now being near the northern. There are at present three small orifices from which the water flows. Two of these are, however very small and from them the flow is hardly appreciable. The third the most northerly, is the largest and from it the water flows freely in quantities sufficient to be utilized. This orifice is in the form of a small basin a few feet in diameter and in this the gases, chiefly carbonic acid gas, keep constantly bubbling up through the water. The basin always remains full and from it there is a constant overflow which passes over the surface of the calcareous deposit and so into the creek. There is no ferruginous deposition nor coating from the waters which flow from this orifice but from the small one at the southern end a decided ochreous looking film coats the sides and bottom of the small runlet which carries off the overflow. The creek is perennial and the overflow water from the spring which finds its way into it is so diluted by the waters of the creek that, below the spring, the slightly distinctive taste and qualities of the spring water are entirely lost.

The water as it issues from the spring appears somewhat milky from the quantity of minute bubbles of carbonic acid gas rising through it. The ebullition caused by the larger bubbles gives it an appearance as if it were boiling. It is slightly tepid, when the hand is introduced into it, its temperature being a little above the average summer heat.

It will be seen from the comparison of the analyses given below that in general chemical constitution this spring water approximates in the comparative abundance of the principal salts to the water from the Saratoga Seltzer Spring, New York State, United States. It is, however, not a saline water, like the latter, the bulk of the soda being in the form of a carbonate. It is a carbonated water, but there is not sufficient iron present to make it chalybeate. It is too hard to be potable. There is nothing disagreeable in its taste nor smell, in fact it tastes like ordinary soda water. So far as it has been tested it contains no albuminoid nor ammonia. No deleterious effect follows even a free use of this water.

	Saratoga Seltzer Springs. *		Soda Water, Cooma. †		Ballimore Springs. ‡
	grs. per gallon.		grs. per gallon.		grs. per gallon.
Carborate of Iron	1·70	......	1·40	Iron	0·70
Bicarbonate of Calcium	89·87	Calcium	40·10	Calcium	......
Phosphate ,,	trace		......		11·38
Fluoride ,,	trace		......		......
Bicarbonate of Sodium	29·43	Sodium	42·95	Sodium	183 10
Phosphate ,,	trace		......		......
Biborate ,,	trace		......		......
Chloride ,,	134·29		3·98		6·92
Iodide ,,	0·03		......		......
Bromide ,,	0·63		......		......
Bicarbonate of Magnesium	40·34	......	22·35	......	9·36
Sulphate of Potassium	0·56	Carb. of Potassium	3·50	Potassium	12·83
Chloride ,,	1·34		......		......
Bicarbonate of Lithium	0·90	......	0·21	Lithium	0·05
Bicarbonate of Strontium	trace	......	......	Strontium	trace
Bicarbonate of Barium	trace	......	......	......	......
Silica	2·56	......	1·03	......	0·28
Alumina	0·37	......	......	......	trace
Boracic Acid	trace	......	......	......	......
Organic matter	trace	......	13·40	......	......
	302·02		128·92		224·62
Carbonic Acid	324·08	......	24·81		

Ballimore water also contains free ammonia ...... 0·052 parts per 100,000 parts.
and albuminoid ammonia ...... 0·003 ,, ,, ,,

An analysis of the mineral water from near Ballimore Hill, to the east of Dubbo, is given for comparison with the Cooma water. It is not, however, a natural spring, but an artesian supply which was tapped while boring for coal. It rises from a depth of over 500 feet from among a series of horizontally bedded sandstones and shales, which form a partially isolated basin, the Talbragar River Coal-field, belonging to the Carboniferous system. The supply from this source is very copious, and far exceeds that from the Rock Flat spring, but from its chemical composition the latter is better adapted for commercial uses.

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* Bulletin of United States Geological Survey, No. 32, p. 40.
† Ann. Report Dept. Mines, N. S. Wales, for 1879 [1880], p. 48.
‡ Ann. Report Dept. Mines, N. S. Wales, for 1887 [1888], p. 47.

Two other analyses of the Rock Flat spring water are given below, but in these the relative quantities of individual salts have not been tested for :—

	Gr. per gallon.	Gr. per gallon.
Total solids	**134·02**[*]	**133·98**[†]
Soluble solids	**59·96**	**62·77**
Insoluble solids	**74·06**	**71·21**
Chlorine	**29·51**	**14·78**
Equivalents in Na. Cl	**48·60**	**24·35**

The insoluble solids consist of carbonate and sulphate of lime, silica, and carbonate of iron. The soluble solids consist chiefly of chloride and carbonate of soda.

Waters containing abnormal quantities of various chemical salts, thus constituting mineral waters, are known to occur in different parts of the country, but so far none of them have ever been utilized commercially nor even to any extent as public resorts. The value of these waters for either purpose depends chiefly upon the presence of certain chemical salts which possess certain therapeutic actions, and the absence of others which have a deleterious effect upon the human system. Of the medical value of our mineral waters we know as yet little or nothing, and there certainly a wide field for research open to specialists in materia medica who are disposed to investigate the medicinal properties and therapeutic actions of the mineral waters of this country.

There is no reason why, as an industry, the preparation of such of our mineral waters as will advantageously lend themselves to the process, may not in course of time be a large and important one, and as public resorts, many of these springs cannot fail to become both commercially and medicinally of great public value and utility. Mr. Isaac Millner, of Sydney, has, I believe, within the last few months had the chief orifice of the Rock Flat spring cleaned out and slabbed down to the silurian bed-rock, to facilitate the collection of the water prior to its preparation for use at a distance. It is to be hoped that this venture will prove to be the initial step towards the extensive development of the commercial and medicinal uses of the mineral waters of this Colony.

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[*] Ann. Report Dept. Mines, N. S. Wales, for 1885 [1886], p. 41.

[†] Ann. Report Dept. Mines, N. S. Wales, for 1885 [1886], p. 42.

PLATE XXV.

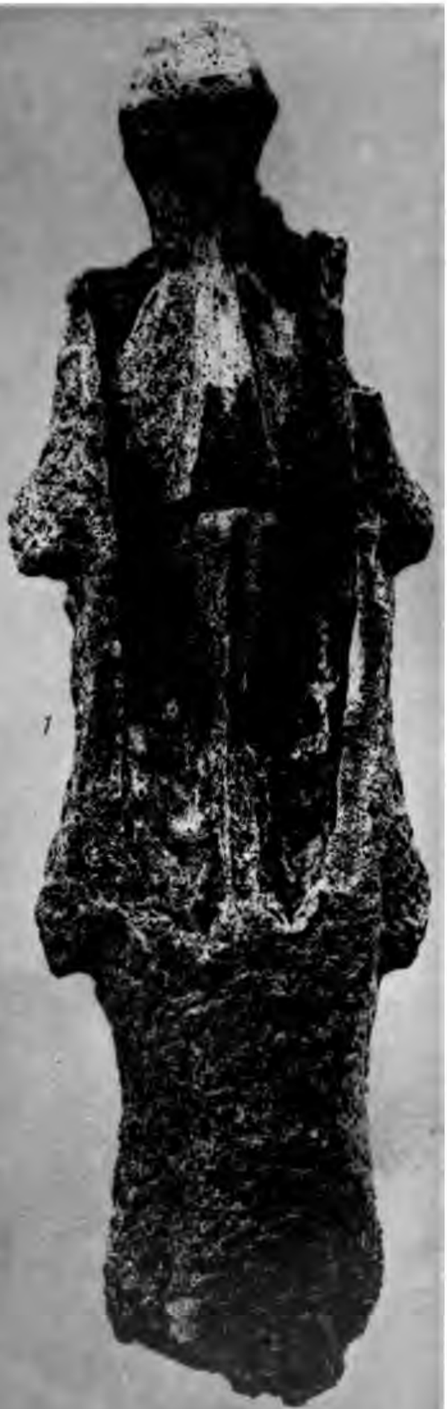
Meiolania platyceps, *Owen*.

Fig. 1. Ventral view of a tail sheath from Lord Howe Island, showing caudal vertebræ *in situ*.

Fig. 2. Portion of an annular ring of the tail sheath ; Canadian Lead.

Fig. 3. Ventral view of a caudal vertebra ; Canadian Lead.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are of the natural size.



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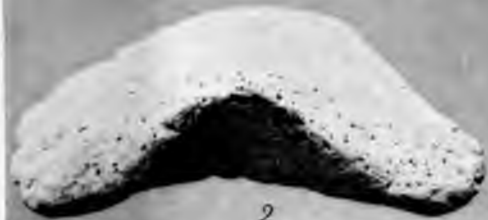

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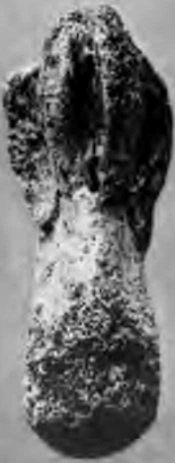

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Reproduced by Heliotype. *11a 227—89*

PLATE XXVI.

Meiolania platyceps, *Owen.*

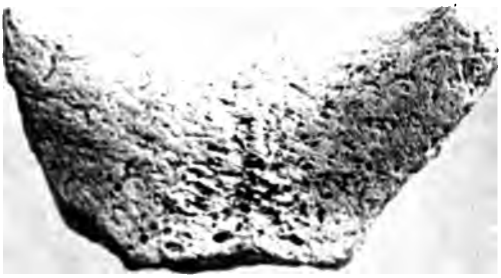
Fig. 1. Side view of a tail sheath from Lord Howe Island.

Fig. 2. Portion of another annular ring from a tail sheath, seen from above; Canadian Lead.

Fig. 3. Side view of caudal vertebra; Canadian Lead.

Fig. 4. Small horn-core seen from the side; Canadian Lead.

The figures from photographs by Mr. H. Barnes, of the Australian Museum, are of the natural size.



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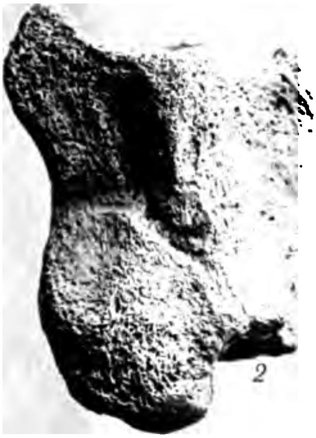

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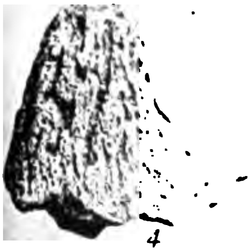

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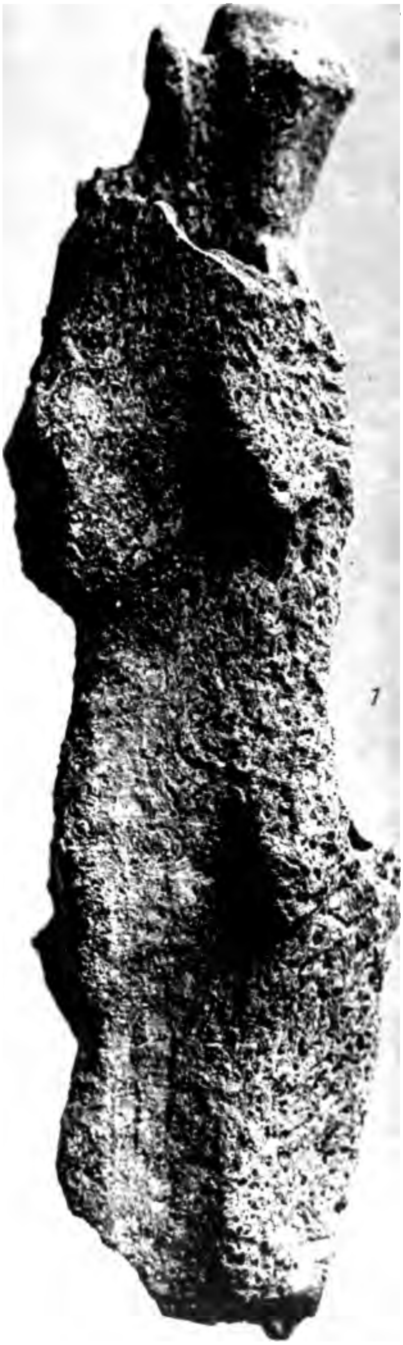

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PLATE XXVII.

Fig. 1. Map of New South Wales showing positions of occurrence of Leucite basalt

Fig. 2. Geological sketch map of vicinity of Byrock.

Fig. 3. Geological sketch map of vicinity of El Capitan.

Index of geological signs used in Figs. 2 and 3.

▧	Granite.	▤	Silurian.	░	Cretaceous
▥	Leucite Basalt.	⩔	Pleistocene red soil.		

Maps drawn by P. T. Hammond.

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PLATE XXVII

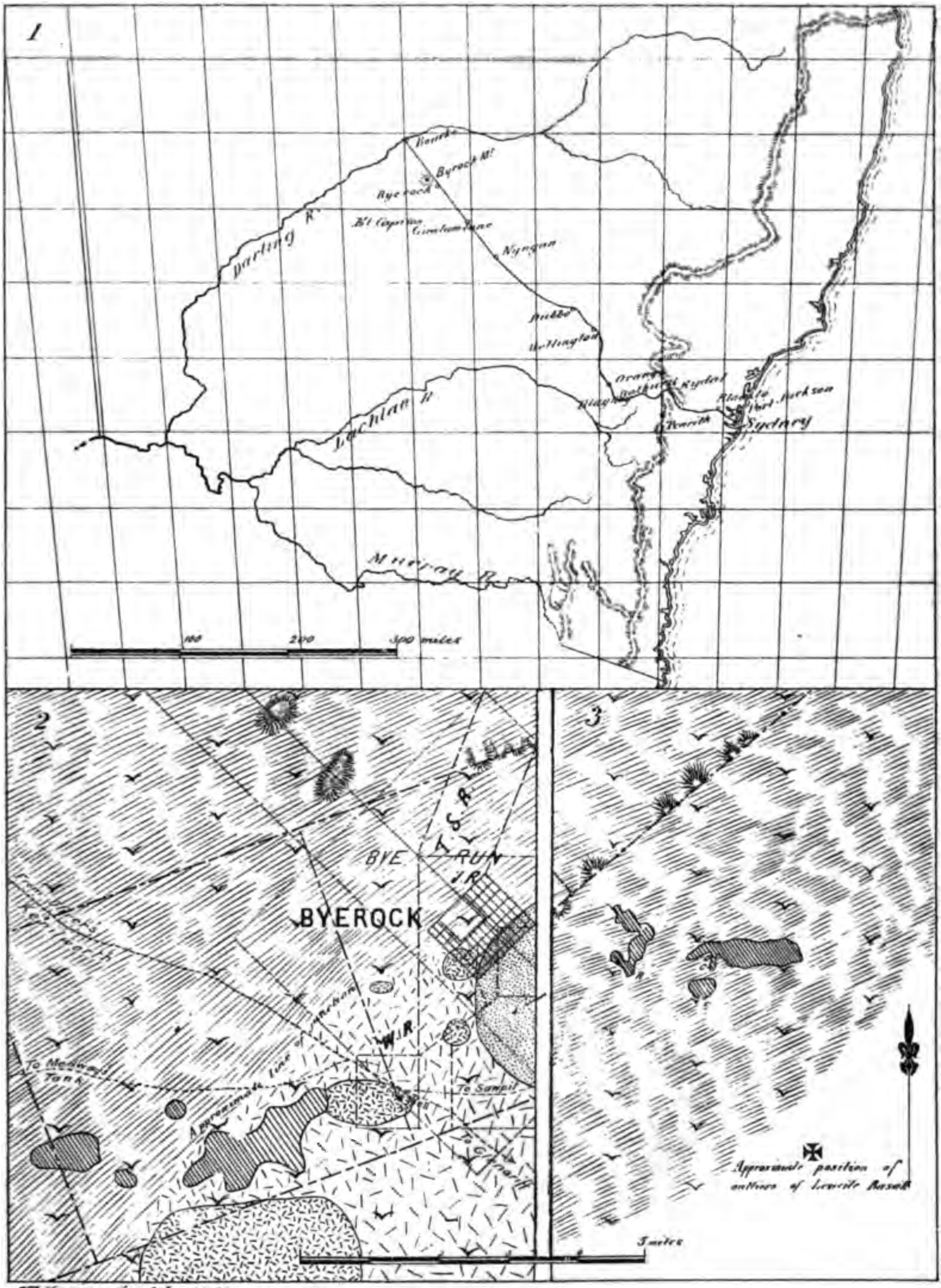

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PLATE XXVIII.

Fig. 1. Showing brecciated character of rock at El Capitan (Slide No. 63*c*).

Fig. 2. Leucite crystals. Showing circular arrangement of glassy inclusions (Slide No. 58); showing branching tubuli (Slide No. 50*a*); showing zonal growth lines (Slide No. 58).

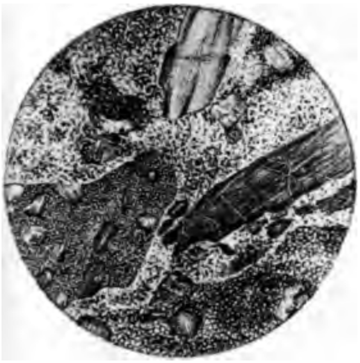
Fig. 3. Olivine crystals showing incipient horizontal lines of decomposition in its early stage (Slide No. 59*b*).

Fig. 4. Showing circular arrangement of leucite crystals around a nucleus of magnetite and mica (Slide No. 58).

Fig. 5. Three crystals of decomposing Olivine. One showing geniculate twinning (Slide No. 52*a*).

Fig. 6. Showing general microscopical structure of typical leucite basalt from Byrock Mountain (Slide No. 52*a*).

All the figures drawn from sections by P. T. Hammond.



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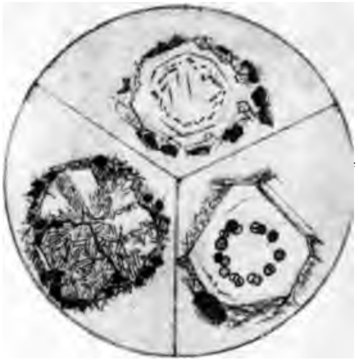

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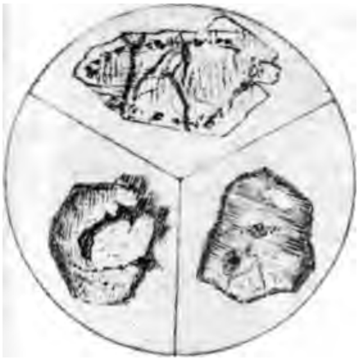

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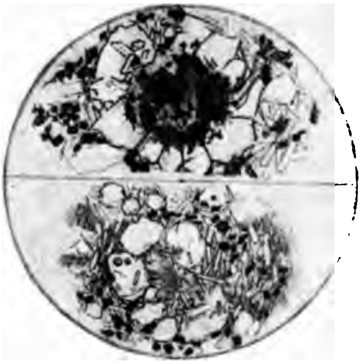

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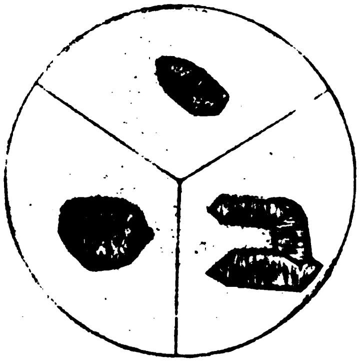

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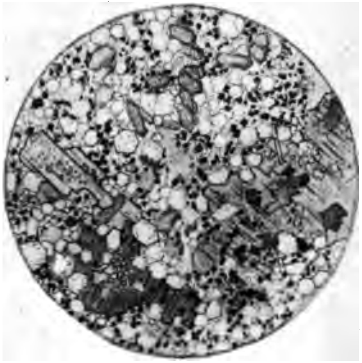

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PLATE XXIX.

Fig. 1. *Stephanoceras*, allied to *S. lamellosus*, J. de C. Sowerby ; Strickland River.

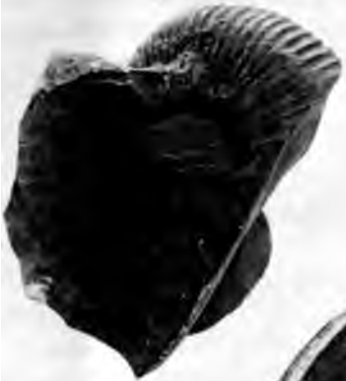
Fig. 2. *Stephanoceras*, allied to *S. Blagdeni*, J. Sowerby ; Strickland River.

Fig. 3. *Stephanoceras*, allied to *S. lamellosus*, J. de C. Sowerby ; Strickland River.

Fig. 4. An Ammonite, allied to *Ammonites lingulatus*, Quenstedt, *teste* H. Woodward ; Strickland River.

Fig. 5. *Stephanoceras*, allied to *S. calloviensis*, Sowerby ; Strickland River

The figures from photographs by Mr. H. Barnes, of the Australian Museum, are reduced nearly one-third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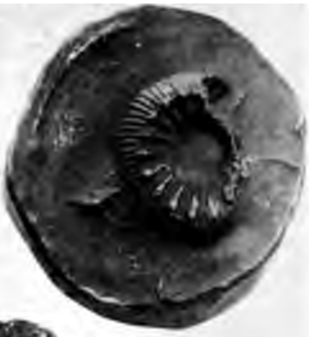
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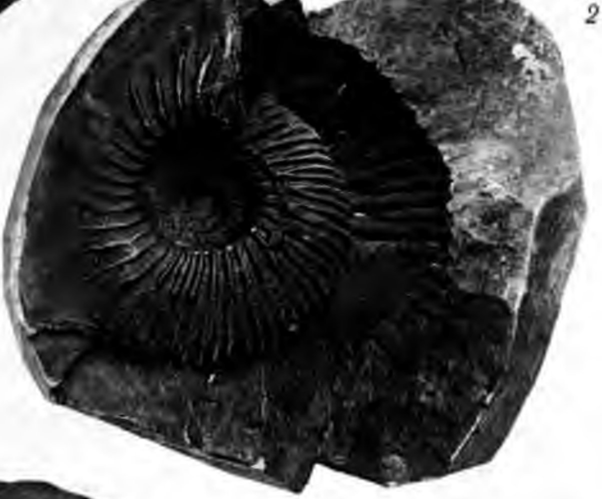
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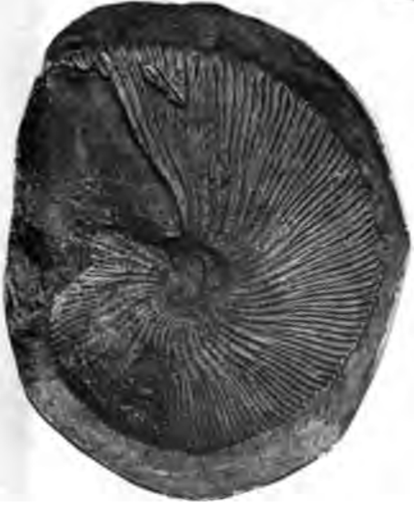
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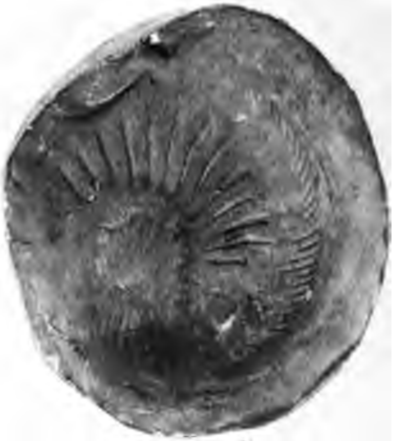
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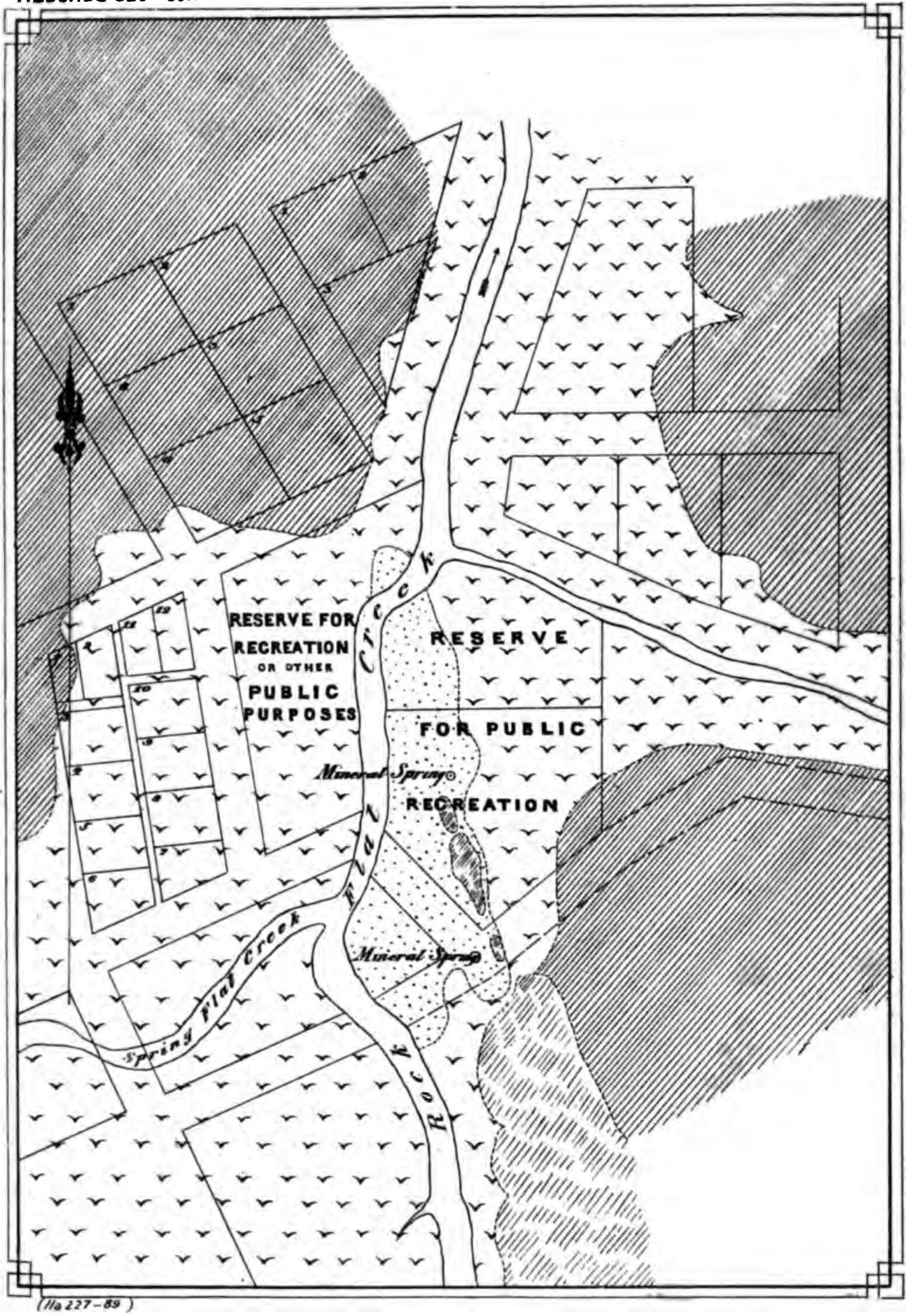
PLATE XXX.

Geological sketch map of the neighbourhood of the Soda Spring, with plan of part of survey in township of Rock Flat.

▨	Tertiary basalt.	░	Calcareous tufa.
▩	Siluro-Devonian quartzite.	vvv	Pleistocene alluvia.

Map drawn by P. T. Hammond.

PLATE XXX


RESERVE FOR RECREATION OR OTHER PUBLIC PURPOSES
RESERVE FOR PUBLIC RECREATION
Mineral Spring
Mineral Spring
Rock Flat Creek
Spring Flat Creek

(IIa 227-89)

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SYDNEY, NEW SOUTH WALES.

CATALOGUE OF MINING MAPS

PUBLISHED BY THE

DEPARTMENT OF MINES, SYDNEY, NEW SOUTH WALES,

1st JANUARY, 1889.

To be obtained at the Department of Mines, Sydney, and at the Warden's Office in the Mining District in which the land represented on the map or plan is situated.

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ALBERT MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Albert	Yancowinna	Thackaringa.	Mount Gipps	Yancowinna	Silverton.
Alma	do	"The Pinnacles."	Moorkaie	do	do Mount Gipps.
Alberta	Farnell	Corona.	Naradin	do	do
Bomangaldy	Yancowinna	Silverton.	Purnamoota	do	do
Bray	do	do	Picton	do	do Broken Hill.
Bolaira	do	Silverton, Round Hill.	Robe	do	do Purnamoota.
Bligh	Farnell	Corona.	Stephen	do	do
Badjerrigarn	do	do	Soudan	do	do
Byjerkerno	do	Poolamacca.	Sebastopol	do	do Rockwell Paddock.
Corona	do	Corona.	Tara	do	do Piesse's Nob.
Edgar	Yancowinna	Silverton.	Umberumberka	do	do
Fowler's Gap (see Giles)	Farnell		Wankeroo	do	do
Giles	do	Fowler's Gap.	Yancowinna	do	do
Lewis	Yancowinna	Silverton.			

BATHURST MINING DISTRICT.

Bolton (a)	Westmoreland	Wiseman's Creek.	Jocelyn	Westmoreland	Wiseman's Creek.
Baring	do		Langdale	do	do
Castleton	Roxburgh	Sunny Corner.	Lennox	Bathurst	Ophir Gold-field.
Coolamigal (b)	do	do	Lewis	do	do
Cullen Bullen	do	do	Mulgunnia	Georgiana	Mulgunnia Gold-field.
Eskdale	do	Clear Creek and Kirkconnell Gold-field.	Oberon	Westmoreland	Oberon Gold-field.
			Tuena	Georgiana	Abercrombie Gold-field.
Falnash	do	Sunny Corner.	Worcester	Bathurst	Ophir Gold-field.
Gilliudich	Georgiana	Junction Point, Tuena Creek, and Markdale Gold-fields.	Do	do	do
				(Survey Office litho. adopted.)	

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nullama	Gresham	Boyd or Little River Gold-field. (Survey Office litho. adopted.)

HUNTER AND MACLEAY MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bindera	Gloucester	Barrington Gold-field.	Craven	Gloucester	Barrington Gold-field.

LACHLAN MINING DISTRICT.

Bundawarrah	Bland	Temora Gold-field.	Parkes	Ashburnham	Billabong Gold-field.
Currajong	Ashburnham	Billabong Gold-field.	Young	Monteagle	Burrangong Gold-field.

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Gulgong (a)	Phillip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field.
Guntawang (b)	do	do	Wyaldra	Phillip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

Arvid	Gough	Vegetable Creek.	Land's End (o)	Gough	Emmaville Gold-field.
Annandale	Clive	do	Muir (p)	do	do
Bundar (a)	Gough	do	Marylands (q)	Buller	Wilson's Downfall.
Bookookoorara (b)	Buller	Wilson's Downfall.	Marsh (r)	do	do
Bates (c)	Clive		Paradise North (s)	Gough	Emmaville Gold-field.
Blain (d)	do		Purvis (u)	Clive	
Bowman (e)	do		Ruby (v)	Buller	Wilson's Downfall.
Binghi (f)	do		Rockvale (w)	Clive	Emmaville Gold-field.
Boorook	Buller	Boorook Gold-field.	Rockglen (x)	do	do
Boonoo Boonoo (g)	do	do	Strathbogie	do	do
Corry (h)	do	Wilson's Downfall.	Strathbogie North (y)	do	do
Cullendore (i)	do	do	Scone	do	do
Cranbrook (j)	Clive	Emmaville Gold-field.	Strachan	do	do
Callanyn	Buller	Red Rock.	Silent Grove (a^1)	do	do
Dumaresq (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
Fraser (l)	do	Emmaville Gold-field.	Undercliff (b^1)	Buller	Wilson's Downfall.
Flagstone	do	do	Wellington Vale	Gough	Emmaville Gold-field.
Highland Home	do	do	Wellington North (c^1)	do	do
Hamilton (m)	do	do	Wylie (d^1)	Buller	Wilson's Downfall.
Haystack (n)	do	Vegetable Creek.	West Fairfield	Drake	

PEEL AND URALLA MINING DISTRICT.

Aston	Hardinge	Cope's Creek.	Hall	Darling	Giant's Den.
Bangheet (a)	Murchison	Bingera Diamond-field.	Hall (k)	Murchison	Bingera Gold-field.
Bingera (b)	do	do	Mayo	Hardinge	Cope's Creek.
Boyd (c)	Gough		Mitchell (l)	Gough	
Bloxsome (d)	do		Macintyre (m)	Murchison	Bingera Gold-field.
Bald Nob (e)	do		Metz	Sandon	Hillgrove.
Clive	do	Cope's Creek	Nundle	Parry	Peel River Gold-field.
Clare	Hardinge	do	Swinton	Hardinge	Cope's Creek
Cope's Creek	do	do	Severn (n)	Gough	
Coventry	Clarke		Scott (o)	do	
Cooney	Sandon	Hillgrove.	Sara (p)	Gresham	Mitchell River.
Darby	Hardinge	Cope's Creek.	Scone and Strathbogie	(See New England Mining District.)	
Dungowan (f)	Parry	Peel River Gold-field.			
Dinoga (g)	Murchison	Bingera Gold field.			
Derra Derra (h)	do	do Diamond-field.	Tienga	Hardinge	Cope's Creek.
Gouron (i)	do	do do	Worra (q)	Gresham	Mitchell River.
Herbert	Gough	Cope's Creek.	Wood's Reef	Darling	Ironbark Gold-field.
Hanning	Inglis		Wellington Vale	(See New England Mining District.)	
Hall (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nerrimunga	Argyle	Nerrimunga Gold-field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Carroll (a)	Wellington	Hill End and Tambaroora.	Cummings (b)	Wellington	Hill End and Tambaroora
Tambaroora	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

Adelong (a)	Wynyard	Adelong Gold-field.	**Ellerslie (e)**	Wynyard	Adelong Gold-field.
Bullongong (b)	Murray	Captain's Flat.	**Euadera (f)**	do	do
Ballallaba (c)	do	do	**Gadara (g)**	do	do
Calafat (d)	Wynyard	Adelong Gold-field.	**Wodalga (h)**	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL. II.

1890-92.

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1892.

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DEPARTMENT OF MINES, SYDNEY.

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VOL. II, PART I.

1890.

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N.B.—The map to illustrate Mr. W. Anderson's "Notes on the Tertiary Deep Lead at Tumbarumba" can be had on application at the Geological Branch, Department of Mines, Sydney.

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DEPARTMENT OF MINES, SYDNEY.

RECORDS

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GEOLOGICAL SURVEY OF NEW SOUTH WALES,

Vol. II.] 1890. [Part 1.

I.—Proposed Petrological Classification for the Rocks of New South Wales: by T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor.

It is proposed to divide the rocks of New South Wales into three groups, *Sedimentary, Eruptive, and Altered.*

The term Sedimentary, as used by the Survey, will include not only sediments deposited from water, but also those deposited from the air, such as are formed from the dust-storms prevalent at the Barrier Ranges and elsewhere in the Western plains of New South Wales, as described by Mr. C. S. Wilkinson, Geological Surveyor-in-Charge.

The term will further include all wind-formed (Æolian) rocks, whether wholly formed by wind or partly by wind, and partly by water, though it is very doubtful whether any true representatives of the former class exist in New South Wales, which is a sufficient reason for not separating the Æolian from the water-formed rocks. The term *Sedimentary* appears to be preferable to Aqueous, and to Clastic or Fragmental, for the term Aqueous is a less comprehensive term than the one proposed. To the terms Clastic and Fragmental it can be objected that they introduce at once among Sedimentary rocks Eruptive rocks, such as tuffs, which seems unnatural; and further, if these terms be used, the term Crystalline must be employed antithetically; and the latter term necessitates the grouping together of rocks of such widely dissimilar origin as granite, marble, and rock-salt.

It may be objected to the term Sedimentary that it is not strictly applicable to masses of rubble and talus at the foot of precipices, but it is of course impossible to find any single term not open to some objection, and the term Sedimentary seems the least objectionable one under which to include the classes of rock ranged under it in the present scheme. No provision is made in the scheme for extra-terrestrial rocks, such as meteorites and cosmic dust, but they may be grouped by themselves under the head of extra-terrestrial rocks. The dolomites of New South Wales, which as described by C. S. Wilkinson, have a thickness in the Barrier Ranges of about five hundred feet, have been classed provisionally with the chemically formed Sedimentary rocks, but it is doubtful whether they had not better be placed in the B division of the Altered rocks.

As regards the term *Eruptive* it appears to be preferable to the terms, *Igneous*, *Hydrothermal*, and *Crystalline*, for Igneous is obviously a misnomer in its Latin acceptation, meaning fire rather than heat, certainly not moist heat; *Hydrothermal* has the objection of being as equally applicable to the altered rocks as to the Eruptive,; and an objection to the term *Crystalline*, besides those already mentioned, is that it excludes all the glassy types of Eruptive rocks from the rest of the Eruptives, which is an unnatural separation.

As regards the sub-divisions of the Eruptive rocks, the first two proposed are the Massive and the Tuffaceous. Massive is adopted here rather than Crystalline, because Crystalline excludes the glassy types. An alternative term for Tuffaceous is Pyroclastic, but the same objection applies to Pyroclastic as to Igneous, viz., that it is a misnomer as regards its signification of the agency of fire. It may be objected that Tuffaceous is liable to be confounded with Tufaceous, and perhaps it might be better to substitute the term Tuffs for Tuffaceous, but the adjective Tuffaceous is preferable as opposed to the adjective Massive.

As regards the classing of the glassy or vitreous types of rock there exists at present a considerable looseness of nomenclature among petrologists, arising naturally from the greater difficulty of differentiating volcanic glasses as compared with the holocrystalline eruptives, of which they are the representatives, from the absence of any well-defined crystallised minerals in the volcanic glasses. Thus the term Pitchstone is often applied to probably glassy varieties of trachyte and andesite, as well as to obsidians and rhyolites, which two last are of course true representatives of the acid group.

Similarly the term tachylyte is loosely used to express glassy representatives probably of all the different varieties of basaltic rocks, usually occurring in a microcrystalline or holocrystalline condition.

Some doubt may be entertained as to the propriety of retaining diabase as a division separate from the basic dolerites, instead of grouping it under the latter rocks, as the finely crystalline varities of diabase when of a volcanic character nearly approach the plagioclose-basalts on one side, and the augite-andesites on the other. An objection also to using the term diabase at all is that by some petrologists it is used as a term for a crystalline granular admixture of triclinic felspar, augite, and magnetite, in which olivine is not, and has, perhaps, never been, present; whereas by others it is used for dolerites which have lost their olivines simply through decomposition, and which, consequently, show in transparent sections under the microscope only triclinic felspar, augite, and magnetite, with various products of alteration representing the decomposed olivine, and often pseudomorphous after it. For such dolerites the adjectival form diabasic should probably be employed. It may, however, be as well for the present to retain the old term diabase, restricting its use to the undecomposed rock consisting of a crystalline granular admixture of triclinic felspar, augite and magnetite, and not employing the term at all unless there appear to be strong reasons for it. In some cases the so-called diabases of this Colony can certainly be referred to coarsely crystalline conditions of dolerite.

Various inconsistencies must exist at present in all classifications of the Eruptive rocks by reason of the very little that is known as to the essentials, which should be taken as constituting distinct rock species, and the present scheme of classification is not free from them.

An inconsistency exists in the attempt to subdivide the massive Eruptive rocks strictly in accordance with their mineralogical constitution. For instance, as pointed out by Professor J. W. Judd,* in the case of some of the lavas termed enstatite-andesites, from Krakatoa, as compared with similarly named rocks from America, Santorin, and England, although these rocks are so classed chiefly on account of their mineralogical constitution, they nevertheless differ widely in ultimate chemical composition, as he shows by the following table:—

	Rocks of Santorin dykes.	Buffalo Peaks lava.	Cheviot Rocks.	Recent lavas of Santorin.	Rocks of Krakatoa.
Silica	51·8	56·6	64·5	67·4	70·0
Alumina..........................	20·1	16·2	16·3	14·8	15·0
Oxides of Iron	11·6	9·3	5·1	6·4	4·0
Lime	11·9	7·8	4·4	3·7	3·7
Magnesia	3·4	4·6	4·2	1·0	1·3
Soda	1·4	3·1	3·4	4·4	4·1
Potash	0·1	2·4	3·1	2·3	1·9

These inconsistencies in classifications, based purely on mineralogical constitution, show the necessity for making ultimate chemical composition the primary basis of subdivision of the Massive Eruptives, and making mineralogical constitution subordinate to it, though even this system of making chemical composition the primary basis of division will obviously have to be abandoned if further research proves it to be unnatural.

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* Geol. Mag., 1888, Dec. III, Vol. V, No. 1, p. 4.

The Tuffaceous rocks are proposed to be divided into *Simple* and *Compound.* Simple Tuffs are defined as being composed purely of Eruptive rocks. It is also possible, however, of course, for some Tuffs to be composed purely of Sedimentary rocks, and some purely of Altered rocks, like clay slate. Examples, however, of Tuffs of this kind are so rare that it appeared hardly necessary to reserve a special class for them.

Altered Rocks.—The term *Altered* appears preferable to the old term *Metamorphic*, as the latter implies that an actual change of form has taken place in the minerals composing the rock, which very inadequately and often incorrectly describes the changes which have taken place, which are more often of a metasomatic rather than of a metamorphic character.

It is proposed in the accompanying scheme to divide the Altered rocks into two groups—(1) those whose origin is known, and (2) those whose origin is unknown.

In the former group are included (1) altered Sedimentary rocks, recognisable as such: (2) Altered Eruptive rocks, recognisable as such, and referable to the particular varieties of Eruptive rocks from which they have been derived, whether Massive or Tuffaceous. For instance, it can be shown in many cases that compact quartzites have been derived from sandstones, lydian stones from mudstone, graphitic slates and schists from carbonaceous clays, hematite and magnetite schists from the alteration of sandy bog-iron ores, apatite rocks probably from ancient coprolite beds or guano deposits, gneisses from the marginal crushing of granite, felsitic slate and schist from pumiceous tuffs, diabasic schists from diabasic tuffs, some mica schists from arkose sandstone.

In such cases as these it might therefore be as well to refer the rock at once to the variety of unaltered rock from which it has been derived.

By far the greater portion, however, of the altered rocks of New South Wales cannot at present be referred to any recognised type of unaltered Sedimentary or Eruptive rock with any certainty. For them, therefore, some provisional arrangement becomes necessary, and it is proposed accordingly to keep them in a group by themselves.

The question of sub-dividing this group is a somewhat difficult one, but the most obvious primary differentia is the chemical composition. It would, however, be impracticable to attempt at present to divide the altered rocks of intermediate composition from those of basic. The test of the presence or absence of free silica, so useful, especially in the field, in classing the rocks of the acid eruptive group, fails when applied to the altered rocks, for the tendency in these, as in all rocks appears to be, whenever conditions are favourable for rearrangement of material, for acidic minerals such as the felspars to break up into more basic minerals, especially micas, with separation of silica. This change is very observable in the tuffaceous sandstones and conglomerates of the Rhacopteris beds of the Port Stephens District, in which secondary mica has been largely developed apparently at the expense of the basic material in the finely comminuted fragments of felspar, and this has probably been accompanied by a separation of silica, as in the case of the arkose sandstones and shists of Lake Superior. Some of these crystals of secondary mica in the Rhacopteris beds are over half inch in diameter.

Mr. Howitt's observations in the Omeo District also show that the crushed felspathic material in the gneisses formed from granites has altered into mica and free silica, which is quite in accord with the artificial experiments of Messrs Fouqué and Michel-Lévy, who found that powdered felspars on heating, under dry heat, formed mica and quartz on recrystallising after cooling, instead of recrystallising as felspar. The conclusion to be drawn from this, therefore, is that free quartz may be expected in the altered rocks even when they have an ultimate chemical composition which is intermediate or even basic. Only, therefore, in the case of those Altered rocks whose composition is decidedly siliceous is it proposed to include them under the acid-eruptive group, such as gneiss, granulite, quartz, schist, &c. At the extreme basic or ultra-basic end of the list serpentine, whether foliated or not, may be safely placed, and the altered rocks of intermediate or basic composition, such as epi-diorite, chlorite rock, chlorite schist, talc schist, sericite schist, &c., may be temporarily included under one group, as proposed in the scheme.

Granite and gneiss have been included doubtfully under the acid Altered rocks. This is contrary to the most recent researches of the bulk of petrologists, who maintain that there is never a passage from a Sedimentary rock into a granite. Against this, however, must be adduced the fact that intrusive granite is occasionally found immediately underneath rocks even of secondary age, not merely in dykes, but even in broad eruptive masses, as in the Vancouver Series of the Dominion of Canada, where instrusive granite immediately underlies Triassic rocks. Obviously these Triassic rocks must have been laid down on an old floor of Sedimentary or Eruptive rock, and what, then, can have become of that floor unless it has been gradually dissolved and absorbed into the mass of the eruptive granite, in the same manner as the fragments of the Triassic rocks, entangled in the granite along its junction line with the Trias, are described as having been partially absorbed.*

The following description of the relation of the granite of Vancouver Island to the Triassic Vancouver Series has such an important bearing on the classing of the Altered rocks that there is sufficient excuse for quoting Dr. Dawson's words here, as follows:—"The circumstances attending the line of junction of the granites with the rocks of the Vancouver Series have been carefully examined at a great number of points. The granites near this line are usually charged with innumerable darker fragments of the Vancouver Series, which, when in the immediate vicinity of the parent rock, are angular and clearly marked, but at a greater distance become rounded and blurred in outline, and might then be mistaken for concretionary masses in the granite, into the substance of which they have been in process of being absorbed. The width of the belt characterized by these fragments is very variable, and where the plane of the present surface cuts that of the junction of the two classes of rocks at an acute angle, as is often the case, it is considerable, frequently exceeding half a mile."

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* On a Geological Examination of the Northern part of Vancouver Island and adjacent coast. Geol. Nat. Hist Survey Canada, Ann. Report, 1886 II. Report B., pp. 11-13, by Dr. G. M. Dawson.

The possible conversion of Sedimentary rocks into granite as above suggested by Dr. Dawson, is confirmed by Mr. A. C. Lawson's observations on the relation of the Lower Archæan (Laurentian) to the Upper Archæan, as studied in the Lake of the Woods and Rainy Districts, over an area of about thirty thousand square miles. Mr. A. C. Lawson concludes that the intrusive nature of the Laurentian rocks along their junction line with the Upper Archæan is due to the Laurentian rocks, at a time subsequent to that when they formed the floor on which the Upper Archæan were deposited, having passed into a state of fusion, the superincumbent Upper Archæan remaining unfused.*

Such observations as these justify the retention of a place, temporarily at any rate, for some granites and some gneisses among the altered Sedimentary rocks.

The expediency of including rocks altered merely by somewhat superficial weathering, such as laterite, palagonite tuff, melaphyre, and wacke among the *Altered Rocks* may seem questionable. Deposits of kaolin might with equal propriety, perhaps, be also so classed.

It might subsequently be found to be convenient to distinguish between rocks altered by chemical action set up by air and rain water, down to a comparatively shallow depth, and rocks altered by deep-seated chemical action.

This scheme of classification is intended only as a tentative one to be applied provisionally for classing the rocks of New South Wales, and to be modified, added to, or completely recast, wherever it can be proved to be at variance with nature. Appended are:—

(1) Scheme of Classification for the Rocks of New South Wales.

(2) Lettering of Formations to be used for Maps and Sections by the Geological Survey of New South Wales.

(3) Signs to be used for Maps and Sections by the Geological Survey of New South Wales.

The scheme of colours for the geological maps and sections is almost finally agreed upon, and will shortly be published.

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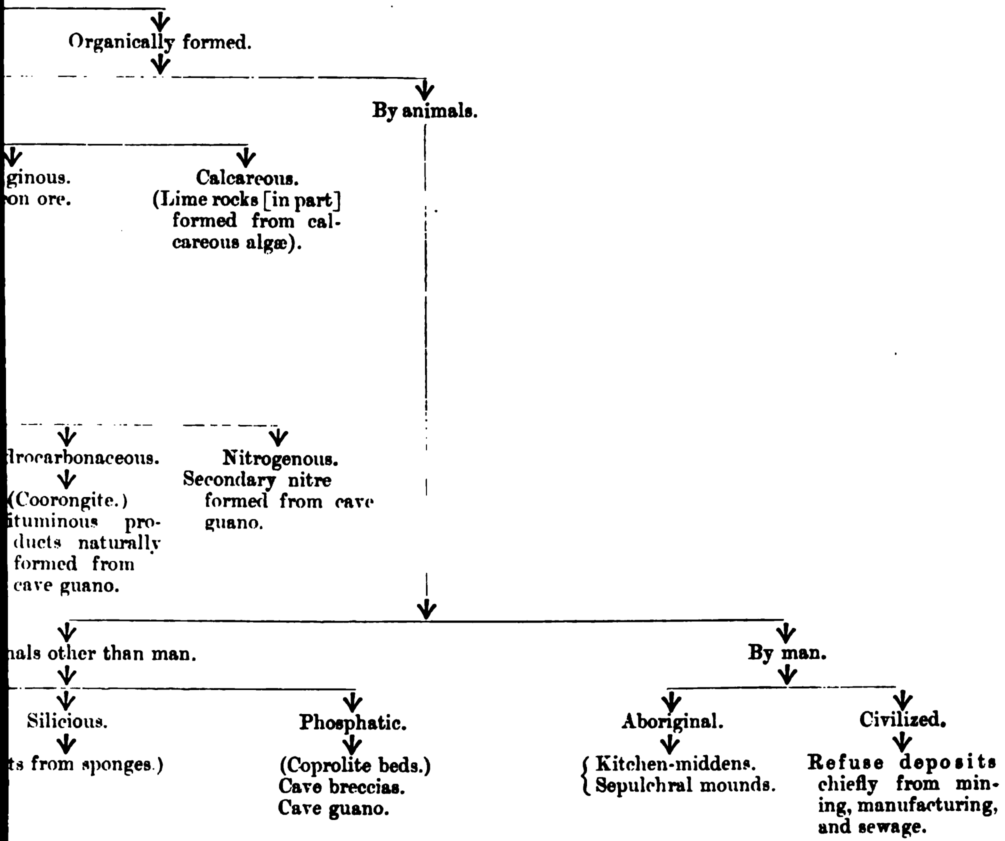
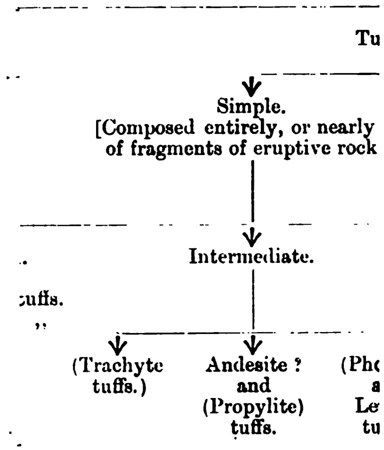
* Congrès Géologique International, 4me Session—Londres, 1888. Etudes sur les Schistes cristallins, pp. 81-82.


Organically formed.
By animals.
ginous.
on ore.
Calcareous.
(Lime rocks [in part] formed from calcareous algæ).
lrocarbonaceous.
(Coorongite.)
ituminous products naturally formed from cave guano.
Nitrogenous.
Secondary nitre formed from cave guano.
als other than man.
By man.
Silicious.
ts from sponges.)
Phosphatic.
(Coprolite beds.)
Cave breccias.
Cave guano.
Aboriginal.
Kitchen-middens.
Sepulchral mounds.
Civilized.
Refuse deposits chiefly from mining, manufacturing, and sewage.



NOTE.—Some of these tuffs can
they belong. For instance, Andesite
without-quartz tuffs, augite-andesite

LETTERING OF FORMATIONS TO BE USED FOR MAPS AND SECTIONS BY THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

ALTERED—

A. Altered rocks whose origin is known to be marked with the letter or symbol of the rock, whether eruptive or sedimentary, from which they have been derived.

B. Whose origin is unknown ... X

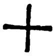
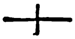
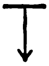
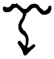
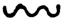
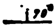
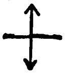
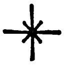
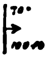
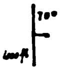
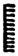
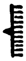
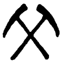
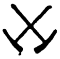
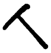
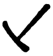
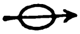
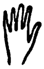
SEDIMENTARY—

CAMBRIAN	P
SILURIAN	Ps^{1}, Lower. Ps^{2}, Upper.
DEVONIAN...	Pd^{1}, Lower. Pd^{2}, Upper.
CARBONIFEROUS	Pc^{1}, Lower. Pc^{2}, Upper.
PERMO-CARBONIFEROUS	Pp^{1}, Lower Marine Series. Pp^{2}, Greta Series. Pp^{3}, Upper Marine Series. Pp^{4}, Tomago Series. Pp^{5}, Hexham Series. Pp^{6}, Newcastle Series.
TRIASSIC	Mt^{1}, Narrabeen. Mt^{2}, Hawkesbury. Mt^{3}, Wianamatta.
CRETACEOUS	Mc^{1}, Lower Cretaceous (Rolling Downs of Queensland). Mc^{2}, Upper Cretaceous (Desert Sandstone and Maryborough beds of Queensland).
TERTIARY	Te, Eocene. Tm, Miocene. Tp, Pliocene. Ti, Pleistocene. Tr, Recent.

ERUPTIVE—

The lettering or symbols for the rocks of this class in New South Wales have not yet been agreed upon, but will, it is hoped, be detailed in a subsequent paper, which will also specially deal with the question of the Geological Terms and Nomenclature employed by the Geological Survey of New South Wales.

SIGNS TO BE USED ON MAPS AND SECTIONS BY THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Signs.	
	Horizontal stratification.
	Vertical beds, the longest line showing the strike.
	Angle and direction of dip of inclined strata.
	General dip of undulating beds.
	Contorted strata.
	Dip and strike of cleavage.
	Anticlinal axis.
	Synclinal axis.
	Normal fault.
	Reverse fault.
	Reef of which dip is unknown.
	Reef dipping (angle read from horizontal).
	Mine being worked.
	Mine abandoned.
	Quarry being worked.
	Quarry abandoned.
	Shaft being worked.
	Shaft abandoned.
	Fresh-water spring.
	Mineral or mud spring.
	Point of eruption (carmine circle).
	Glacial striæ.
	Cave shelters.
	Artesian well.
	Bore.

II.—On the Occurrence of the Genus *Tryplasma*, Lonsdale (*Pholidophyllum*, Lindström), and another Coral apparently referable to *Diphyphyllum*, Lonsdale, in the Upper Silurian and Devonian Rocks respectively, of N. S. Wales: By R. ETHERIDGE, Junr., Palæontologist.

[Plate I.]

I.—Genus TRYPLASMA.

IN describing[*] his proposed genus *Pholidophyllum*[†], Dr. G. Lindström made the following remarks respecting Lonsdale's *Tryplasma.* It "should perhaps have been called *Tryplasma* ; but this name having been founded upon a false conception, according to which the septal points and septal plates should be perforated with canals, a supposition caused by the broken lower parts of the points, I proposed the new name . . . . . based upon the peculiarities of the outer scales." I regret that I cannot agree with Dr. Lindström in the abolition of *Tryplasma.* If every generic name in Palæontology is to be abolished because an original misconception as regards its structure was made, few of the older genera would stand. Granting that a genus has been figured and described to the best of an Author's knowledge, and the material before him, to say nothing of his selecting a well known species as the type, it seems difficult to understand, how in common fairness his work can be set aside. I therefore adopt *Tryplasma* as typified by Lonsdale,[‡] and described by Lindström under the name of *Pholidophyllum*, with this exception.—I believe that *Palæocyclus* should be eliminated from the synonyms of the latter.

Dr. Lindström unites with *Tryplasma* (*Pholidophyllum*), a genus described by Dr. W. Dybowski[§] under the name of *Acanthodes*, a union in which I cordially agree, failing to see how they can possibly be separated.

From the Upper Silurian rocks of the neighbourhood of Yass we possess a coral in which we find the character of *Tryplasma* repeated, but with specific differences. This will be spoken of throughout the following remarks as *Tryplasma Lonsdalei* (Pl. I., Figs. 1 to 6).

The corallum is in the condition of a rather loose aggregation of long, slightly flexuous, cylindrical corallites gradually increasing in size upwards from a finely pointed base united laterally by connecting tubes or stolons (Pl. I., Fig. 1) after the manner of the genus *Eridophyllum*, with an average length of three sixteenths of of an inch. The stolons do not appear to have any particular direction of curvature in growth, but are generally horizontal, and are present in all parts of the corallum, from the base upwards, placed at different heights, and not generally passing from corallite to corallite on the same level, although this has been noted in one or two cases. The stolons previous to their junction with the corallites are somewhat swollen or enlarged, decreasing in the middle (Pl. I., Figs. 2 and 5) ; they are hollow, having a similar proper wall to the corallites, not being merely epithecal out growths. Here and there the corallites impinge against one another, through the absence of the stolons; but on the whole the growth of *Tryplasma Lonsdalei* is tolerably regular.

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[*] Bihang K. Svenska Vet. Akad. Handl. Stockholm, 1882, VII, No. 4.

[†] Öfver K. Vet. Akad. Forhandl. Stockholm, 1870 [1871], p. 925.

[‡] Murchison's Geol. Russia, &c., 1845, I, p. 613.

[§] Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 108.

The circular corallites have an average diameter of three-sixteenths of an inch, but at the points of issue of the stoloniferous out-growths the diameter increases to four and five-sixteenths of an inch. The longest corallites observed were three and a-half inches long.

The epitheca is thin, produced into knobs and small processes, but never presenting regular accretion growths or concentric frills, whether single or successively cupuliform as in some other Upper Silurian forms of this genus.

Parietal gemmation is visible in a few instances, and when the corallites are not too crowded, the younger ones spread out from the parent at rather a wide angle.

The internal structure of this coral is typically that of *Tryplasma*, both as figured by Lonsdale and Lindström, the septa playing a very subordinate part as compared with the tabulæ, the latter not reaching completely across the visceral chambers, as I have failed to trace any definite connection between them and the proper wall; in fact there appears to be very little union between the tabulate and septal zones (Pl. I, Fig. 2 and 3). They are very numerous and close, at times a little irregular, often with a slight concavity, and frequently possessing a slight central depression or pit.

The septa are represented by a series of upwardly directed, short, rigid, thorn-like spines projecting into the visceral cavity between each pair of tabulæ for about one-third the width of the corallite (Pl. I, Fig. 2). As many as three tiers are observable in each inter-tabular space, forty septa in a cycle (Pl. I, Fig. 5), alternately primary and secondary, but the difference in length of the two orders is not great. In a horizontal section the septa appear much broken up and dot-like (Pl. I, Fig. 3), which arises from the section having cut the upwardly projecting ends of more than one cycle. Similarly, when a vertical section is made close to one or other of the walls, and excentric, the distal ends of the septa again appear as so many disconnected points. In clearly preserved specimens the sides of the septa appear to be frosted by a coating of microscopic denticles.

One of the chief points brought forward by Lonsdale in his description of *Tryplasma*, consists "in the lamellæ" (*i.e.* the septa) "of the outer area being pierced from the inner surface of the wall through the whole breadth by well defined relatively large foramina, terminating on the inner edge in a distinct row of short tubuli. The presence of such structures appears to be doubted by Lindström, and I believe, rightly so. Lonsdale, it is true, remarks "that the outer envelope was never pierced," but a curious expression is made use of by Dybowski, who says that in his *T. Eichwaldi** the septa do not appear as points, but as a small roundish or oval holes, arranged in longitudinal rows. Is it possible that these are simply the so-called pores of Lonsdale? It would seem to be so, because further on, Lonsdale, as I understand him, appears to regard the foramina as leading into hollow septa. Whatever may be the condition of the European specimens, I can assert, after a long examination of various cross sections of our Australian species, that the septa are perfectly homogeneous in structure, and that no part of the proper wall is perforate. On the other hand, examples occur in which an undoubted apparent poriferous appearance is presented, quite as figured by Lonsdale. Such are visible in our Pl. I, Fig. 4, on the lower left-hand portion of the figure, arranged in longitudinal series between vertical continuous ridges. I was for a long time much perplexed how to account for this obviously different structure. The following explanation will, I think, meet the case. The "pores" are only visible on entirely, or partially decorticated specimens, *i.e.*, on those in which the epitheca and the proper wall, with the septal area, are wholly or in part removed. Now, bearing in mind that the septa are separte thorn-like bodies, which, from the individuality of the tabulate area, would become readily detached, with those portions just mentioned, it naturally follows that the septa would leave their casts or impressions on any earthy matter infilling the intertabular spaces, or which might have intruded itself between the septal and tabulated zones during decomposition or subsequent fossilisation. In fact, I have a specimen which has lately come into my hands from Hatton's Corner, which more or less shows this. The ridges seen in Pl. I, Fig. 4, between the lines of "pores," are, it follows from this, the infilling casts of the longitudinal interseptal loculi. Another point which tends to bear out this view is the fact that, in all vertically weathered or decorticated specimens, the edges of the tabulæ are left exposed, showing the little cohesion which existed between the septal and tabulate areas.

It will now be of interest to compare our coral with *Tryplasma æquabilis* and *T. tubulatum*, the types, acknowledged by Lonsdale in 1845,† and Lindström in 1882. The latter describes two varieties of this species designated by him "*forma primaria*" and "*mutatio*." In the first, the form of the corallum is broad-conical, the width often greater than its length. In the second variety, on the other hand, the corallum is cylindrical. Our species appertains to the latter variety and generally resembles in habit the coral so figured by various authors, as given in Dr.

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* Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 117.

† Lonsdale also mentions as a species of his proposed sub-genus the *Cyathophyllum articulatum*, His., sp. from Gotland, but Dr. Lindström has shown that this is not Hisinger's species, and has included it as a synonym of his *Pholidophyllum tubulatum*.

Lindström's synonomy. We possess no evidence yet that the Australian form was fixed during life by "stolon pipes" (Stolonrören), from the base of the corallum, as in the European species; but from the presence of these organs throughout the other portions of the corallum it is but natural to suppose that they existed also for the purpose in question;[*] at the same time, Dybowski does not figure such rootlets attached to any of the cylindrical (or "mutatio") species of his *Acanthodes*. At first sight the stolons of *T. Lonsdalei* resemble the horizontal uniting bars of *Eridophyllum*, which are also outgrowths of the proper wall, and this is especially the case in those *Eridophylla* in which the central tabulate area is highly developed, but an examination of the respective septal systems at once dispels any preconceived analogy. If I mistake not, uniting stolons are visible in one of the figures of the corals believed by Lonsdale to be *T. articulatum*[†], the central corallite of the figure being united to that on the right hand by two, whilst Dybowski illustrates this structure only in one instance, his species *Acanthodes tubulus*[‡].

In the "*forma primaria*," or broadly conical variety of *Tryplasma* (*Pholidophyllum*) *tubulatum*, as understood by Lindström, the exterior of the corrallum was ornamented by "epithecal scales," compared by this author to the opercular valves of *Goniophyllum*, *Aræopoma*, and other similar genera, and which are said to exist in the compound forms only at times. It is evident also from Dybowski's illustration of *T.* (*Acanthodes*) *rhizophorus* [§], that anchoring stolons existed in this section of the genus. Our specimens of *T. Lonsdalei* being in a great measure denuded of epitheca, little chance has remained for the preservation of these delicate organs.

The septa in the Australian fossil are much less in number than in *Tryplasma tubulatum*, Schl., sp., the former possessing just half those of the latter, or forty in all, twenty primary and twenty secondary; whilst the resemblance between those of *T. Lonsdalei* and the four species figured by Dybowski is very marked. In all the specimens before me the septa appear to be thorn-like, laterly granular, with an upwardly-directed course, a feature as equally well displayed in the Australian as the European fossils, but the length of the septa is apparently a more constant character than in *T. tubulatum*.

The tabulate area is very characteristic in all species of *Tryplasma*, but like Dr. Lindström, I have quite failed to detect any trace of a septal fossula. Dybowski says that in his *T. cylindricus* the tabulæ cease at the inner ends of the septa, and do not reach the proper wall. He accounts for this on the supposition that the septa are too closely placed to one another, and in well prepared thin sections of *T. Lonsdalei* I have not distinctly observed the tabulæ uniting with the proper wall. The tabulæ of the latter species resemble those of *T. rhizophorus*,

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[*] This is highly probable, because stoloniferous rootlets are a characteristic feature and common to many "Anthozoa Operculata."

[†] Murchison's Geol. Russia, &c., 1845, I, t. A., f. 8b.

[‡] Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 114.

[§] *Loc. cit.* t. A, f. 12.

Dyb. sp. and *T. Eichwaldi*, Dyb. sp. more than they do the other species of the genus, and appear to be of the simpler structure in *T. tubulum*, Dyb. sp. In the last-named coral, *T. rhizophorus*, *T. Eichwaldi*, and *T. tubulatum*. Schl. sp., several tiers or cycles of septa occur between every pair of tabulæ, in which *T. Lonsdalei* agrees with them, but in *T. cylindrica* there appears to be a tabulum for each septal cycle.

From the closely intermingled state of the corallites in the blocks from Hatton's Corner it is difficult to distinguish the method of reproduction, but so far as observed the regular calicular gemmation described by Lindström has not been observed. On the contrary, two or three instances certainly demonstrate the presence of parietal budding, thus favouring the description of Lonsdale, who says:—"Chiefly from the sides of the parent stem." Dybowski describes a lateral or parietal gemmation, and figures it in *T. tubulum*, but at the same time remarks on its rarity of occurrence.

In the form of growth Dybowski's genus *Cyathophylloides*,[*] especially *C. fasciculus*, Kutorga,[†] is a similar coral, the somewhat flexuous corallites being united by stolons as in the present instance. The nature of the septa, however, entirely separates the two genera, for in *Cyathophylloides* the septa converge to the centre of the corallites, and the open tabulate area is not present. The latter does not seem to me to differ in any important characters from *Diplophyllum*, Hall.[‡]

II.—Genus DIPHYPHYLLUM.

The adverse opinion of such eminent authorities as Milne Edwards, and Haime, notwithstanding, *Diphyphyllum* has been shown by Messrs. De Koninck, Billings, Nicholson, and Thomson, to be a valid genus, and distinct from *Lithostrotion*, thus confirming the original statement of Mr. W. Lonsdale.[§]

In this genus the corallum is compound, formed of long, usually cylindrical corrallites united in more or less fasciculate groups. Each corallite is clothed in a distinct epitheca. The internal structure is biareal, consisting of an outer and usually well developed septal zone, and an inner tabulate area, but the septa never reach the centre of the visceral chamber, although they may, to some extent, infringe on the tabulate area. The interseptal loculi are occupied by dissepiments, and there is no columella. The developement is by parietal or calicular gemmation.

In the coral from Tamworth (Pl. I, Figs. 7-11), collected by Mr. D. A. Porter, and about to be described, the corallum is in the form of very long, slender, and somewhat delicate cylindrical corallites, usually free, but united by their walls at times, and thus forming loosely fasciculate aggregations. The corallites possess an average diameter of three millimeters.

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[*] Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 123.

[†] See Roemer, Lethæa Geognostica, 1 Thiel, Leth. Pal., lief. 2, 1883, p. 340, f. 67.

[‡] Pal. N. York, 1852, II. p., 115.

[§] Murchison's Geol. Russia &c., 1845, I, p. 622.

In cross section (Pl. I, Figs. 8 and 9) there is revealed a very delicate outer wall, which rapidly becomes destroyed, leaving the proximal ends of the septa projecting as a series of spike-like extensions (Pl. I, Fig. 9), or when seen on the exterior of a weathered specimen, as vertical lamellæ. The septa are about twenty-eight in number, of equal length, and extending inwards barely for half the diameter of the corallites, and dying out on the central tabulate area (Pl. I, Figs. 8 and 9). Here and there one seems to be longer than its fellows, but there is an entire absence of secondary septa in the true sense of the word. The interseptal loculi are divided by two continuous cycles of dissepiments (Pl. I, Figs. 8 and 9), which are so regularly continuous as to give support to the late Professor de Koninck's view of the existence of an inner wall.[*]

The tabulate area occupies nearly two-thirds of the entire diameter of the corallites, and is destitute of the acicular central point described as occasionally existing by Lonsdale.[†] The interseptal loculi between the outer delicate wall and the first cycle of transverse dissepiments invariably appear in cross section to be quite free of subdivisions.

A longitudinal section is equally instructive. The tabulæ are horizontal or oblique; complete, or at times incomplete, their inner edges resting on one another, and then giving to the corallum a more or less vesicular appearance (Pl. I, Figs. 10 and 11). When complete, however, they always appear equidistant, and usually possess the Diphyphylloid character of a downward curvature at the periphery, a character pointed out in this genus by Prof. M'Coy.[‡] On the other hand, there is again no trace of the central break in the tabulæ, resulting in what Mr. James Thomson calls the "columellarian line"[§], when a number of tabulæ are arranged in serial succession, and a continuation of Lonsdale's acicular point. The inner zone is filled with minute very close transverse dissepiments, and convex upwards, or in the direction of the general growth of the corallum (Pl. I, Fig. 10). In a longitudinal section nearer the periphery the vertical and continuous septal lamellæ are at once seen, subdivided into a ladder-like appearance by the transverse dissepiments previously described.

The epitheca is not preserved, and the method of reproduction has not been observed, but from the appearance of the two contiguous corallites (Pl. I, Fig. 8) it would not appear to differ from the method met with in the other species of the genus.

On comparing the structure of this coral with that of *Diphyphyllum*, we notice a community of structure in the biareal form of the corallum, general mode of growth, absence of a columella, presence of the central tabulate area, and the peripheral downward inclination of the tabulæ. On the other hand, the present coral departs from the general structure of *Diphyphyllum* in the much less amount of vesicluar tissue, and the somewhat abnormal method of its arrangement, giving rise to the impression that an inner mural investment was actually present. It further differs in the uniform size of the septa, and the delicate outer wall.

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[*] Nouv. Rech. Anim. Foss. Terr. Carb. Belgique, 1872, Pt. 1, p. 35.

[†] Murchison's Geol. Russia, &c., 1845, I, p. 624.

[‡] Brit. Pal. Foss., 1851, Fascic. 1, p. 88.

[§] Development and Generic Relation of the Corals of the Carboniferous System in Scotland, p. 87 8vo., Glasgow, 1883).

In general outward appearance our specimens (which I purpose calling *Diphyphyllum ? Porteri*) are very much like Hall's genus *Diplophyllum*,* but in the latter the septa are said to pass completely to the centre of the visceral chamber, accompanied by other minor details. In this sense *Diplophyllum* does not appear to differ from *Fasciculario*, Dybowski, and even from *Donacophyllum*, Dybowski.† The specimens were collected by Mr. D. A. Porter, from the Devonian limestones of the neighbourhood of Tamworth, N. S. Wales.

III.—Notes on the Tertiary Deep Lead at Tumbarumba: By WILLIAM ANDERSON, Geological Surveyor.

NEARLY thirty years ago the Tumbarumba valley was extensively worked for gold, which was obtained, chiefly from the Pleistocene and Recent gravels and sands, deposited by the present creek. The gold was no doubt largely derived from the denudation of portions of the Tertiary lead which exists within the drainage area of that creek, although much of it had probably been thrown from reefs in the bed-rock which had undergone denudation during the erosion of the present valley.

The country in the neighbourhood of Tumbarumba is of a somewhat mountainous character, and the varied physical effects produced by the denudation of different kinds of rocks are well seen in the district. Away to the westward of the valley the denudation of the Silurian rocks has produced a smoothly undulating country, well covered with soil of fairly good agricultural quality; while to the eastward, where the country is wholly composed of granite, it has been eroded into rugged gorges, and rough, wild, bare, cliff-girt mountains of forbidding aspect, with poor grass and sparse timber. The Tertiary basalt which extends from near the point where it had junctioned with the Maracle Deep Lead basalt, northward to near Bago, is very narrow, and produces, by its degradation, rich agricultural soil. In the vicinity of Bago Inn, the basaltic plateau is, however, of considerable width and elevation (being over three thousand feet above sea level), and here the quality of the soil is shown by the immense size of the timber growing upon it. The depth of the soil is considerable, and has been fully taken advantage of by innumerable wombats, whose burrowings make it extremely dangerous to ride over the surface.

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* Pal. N. York, 1852, II, p. 115, t. 33, f. 1, &c.

† Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 80.

To the east of Tumbarumba Creek there is a wide development of granite, while to the west of it the country is formed of Silurian slates. These latter have been tilted and indurated to a considerable extent, but in the immediate neighbourhood they have not undergone any further alteration, although towards the Murray River considerable metamorphism has taken place. No fossils have yet been obtained from these slates, but it is very probable that they form a part of the Upper Silurian series which is so largely developed further to the eastward. The granite is probably intrusive, if one may judge from the comparatively slight degree of alteration which is apparent in the slates in the neighbourhood of the junction between the two rocks, but the immediate line of contact cannot be observed in the valley of the Tumbarumba Creek, because it is concealed from view below the Tertiary basalt which covers the deep lead. The Tertiary valley, now represented by the deep lead, has been eroded for a long distance in the vicinity of Tumbarumba, along the junction-line between the granite and the slate. Such contact lines offer less resistance to the eroding action of stream-water than otherwise intact rock masses do, and therefore the main direction of many river eroded valleys often follow them with great persistance. The eruption of the lava which partially filled the Tertiary valley seems not to have affected the general level of the country to any appreciable extent, for the main line of drainage still remains approximately the same, and the Tumbarumba Creek, doubtless for some time, continued to flow down the Tertiary valley on the top of the basalt, but ultimately the waters found it easier to erode a passage through the granite, which formed the eastern valley slope; and now we find the upper and greater part of the present valley excavated in that rock. A short distance below the township, however, the creek has worn its way through the basalt and crossed to its western edge, and from this point to its junction with Burra Creek the present valley has been eroded in the Silurian slates, having the basalt for its western slope.

In positions where sections of the lower part of the basalt can be seen it has a columnar structure, while the upper part of the flow is compact. It never attains any great thickness. In one section, exposed on Macabe's Creek, to the south of the township, there is, apparently, a distinct line of demarcation between the lower columnar, and the upper compact basalt. It is, therefore, probable that there were two lava flows, one following rapidly upon the other. Macroscopically the rock is, as a rule, fine-grained and compact, of a greyish-black colour, having small macroscopic crystals of olivine scattered through it. It presents the general appearance of a Tertiary basaltic lava. Microscopically (Slides Nos. 69 and 70) it consists of an aphanitic base, formed of triclinic felspar, augite and magnetite, among which a few large porphyritic crystals of olivine are developed. Minute patches of glass are present in the base. The olivines are much cracked, but otherwise slightly altered, only small portions of the crystals having undergone serpentinisation, which, under a high power, has a minutely reticulated appearance for a varying distance from the cracks into the fresh olivine. There are no striking microscopical features to particularise this rock from the general run of Tertiary basalts.

The granite varies much in texture, but is, as a rule, moderately coarse-grained, although occasionally it is locally largely porphyritic. Its general colour is whitish-grey, the felspar and quartz, speckled with black mica. It is an easily degraded rock, and is readily shattered when slightly decomposed, because the crystals of its various constituents are but loosely held together. Microscopically it consists of two kinds of felspar, orthoclase and a triclinic felspar, which is probably albite, quartz and mica, with a little chlorite, which may be altered hornblende. Exceedingly fine needles of apatite occur as inclusions in the other minerals. Some of the triclinic felspars show a zonal polarisation, and they generally contain a good deal of opaque dusty matter arranged along their twinning planes. The mica assumes two forms, one a light, almost colourless variety, showing the striations very distinctly, and a dark-brown variety, in which the striated character is lost. There is little doubt that the latter is an alteration of the former, because in some sections the clear striated mica is seen to pass into the darker unstriated form.

In many of the large denuded granite blocks lying on the surface, and also in naturally exposed sections of the granite small dark-coloured patches occur, which at first sight were readily mistaken for aggregations of mica, &c., but, on closer examination, their outlines were found to be well-marked and they possessed a generally ellipsoidal form. In size they vary from a few inches in their longer diameter to as much as a couple of feet, and very often they have a distinctly laminated appearance, the laminæ being usually parallel with the longer axis. Microscopically they have all the appearance of rounded pieces of sedimentary rock which have undergone considerable alteration. In microscopical section (slides Nos. 73, 74, 75) they are seen to be distinctly crystalline in structure, and the apparent lamination is due to the arrangement of the various minerals in alternate layers. The rock is quite distinct from the granite and consists of quartz and mica, the flakes of the latter mineral being arranged in a linear manner parallel to the longer axis of the fragments. The dividing line between the two rocks can readily be traced under the microscope, and the minute quartzes and micas of the finer grained rock fill up the minute bays left between the larger crystals of the granite, but in no instance are any of the larger granitic crystals completely surrounded by them. In Slide No. 73, the central portion of the fragment consists chiefly of quartz, with green coloured hornblende, while towards the periphery it is much finer grained, and contains the ordinary brown mica.. This rock, therefore, differs widely from the other fragments and from the general granitic rock in which it occurs, as there is little or no primary hornblende in the granite, although there is some chlorite which might be an alteration of hornblende. These laminated fragments in the granite are at present in the form of mica—and hornblende—schists, and from their composition and mode of occurrence, they would seem to be foreign to the granite. They may be the remnants of the original rocks from the melting of which the granite was formed, or they may be the altered remains of masses of the strata through which the granite was intruded, which were caught up by it when in a liquid state. They are certainly not aggregations, nor is it likely that they are crystallisations of the fluid magma from which the granite was finally crystallised. It is just possible, however, that they may be the residue of a previous local crystallisation before the magma was finally consolidated into its present granitic form, and that the laminated appearance may be due to local pressure induced by the subsequent final consolidation of the granite. They are altogether unlike any of the slatey sedimentary rocks that occur in the district, and among which the granite has been intruded. Although there is, to a certain extent, an intercrystallisation between them and the granite, yet the dividing line between the two rocks is distinctly recognisable, and their peripheral structure differs in a slight degree from that of their centres, thus showing that crystallisation had taken place in these two positions under different conditions, the peripheral zone being more affected by the outside fluid granitic magma than the central part. I have noticed occurrences, similar to the above, in the granite which covers a large area in the neighbourhood of Moruya, in the southern coastal district; while in a granite which occurs between Bendemeer and the Northern Railway line, I have observed masses of highly-altered sedimentary rocks, which have undoubtedly been caught up by the intruding granite, and which have not wholly undergone liquefaction, but remain as identifiable sedimentary rocks, although considerably altered.

The general course of the Tertiary river valley is well defined by the run of basalt, although the latter does not now, in its whole course, cover the channel proper, because it has been denuded so unequally upon both edges of the flow, that in many places merely the basalt which covered portions of the sides of the Tertiary valley is present, the greater part of the drift having been denuded away with the overlying basalt, and its contained gold having been thrown into the Pleistocene alluvium of the present valley. At the northern extremity of that portion of the basalt known as the "Sounding-ground," the basalt as seen on the map is Y-shaped, one arm passing northward towards Tarcutta Creek and the other passing up the Tumbarumba Valley, while the area between these two arms is occupied by a high granite mountain. Some two miles south of "Bago Inn" there is a small lake in the basalt the water of which seldom alters its level. This probably represents one of the points of eruption from which the lava flowed. The flow proceeded southwards, and passed round the eastern side of the above mentioned granite mountain to the south of which the old valley took a somewhat sharp turn to the south-eastward. At this point it flowed against the western side of the valley, which presented itself almost at right angles to the direction of flow. The main bulk of the lava continued its course further down the valley, but a considerable portion of it took a north-westerly course, and flowed backwards for some distance up the valley, lying to the west of the granite mountain. The junction of these two valleys represented by the basalt at the base of the two arms would therefore be a good place to prospect.

The deep lead represented by the flow of basaltic lava has been, as yet, very little worked. Most of the work that has been done in the district has been in the washing of the gold from the Pleistocene drifts in the present valley, in which the quantity of gold has been largely augmented locally by the denudation of portions of the Tertiary Lead. This work has chiefly been carried on by utilising the waters of the creek whose course has been locally turned for the purpose of sluicing certain areas of drift in its neighbourhood. What little work has been done on the lead itself has been by sluicing by means of head races, which have been carried for long distances down the sides of the valley. There are only a few points in the course of the lead where this has been done, so that those portions of it which still exist under the basalt are practically untouched. At one spot, some distance below the township, a shaft has been sunk through the basalt on the lead, but payable drift has not yet been struck there. At various points along the denuded edges of the basalt perennial springs flow from below it. These are probably natural outlets for the drainage, either of the drifts in the gutter proper, or of pervious beds among the pipeclays, and they would therefore be favourable positions for prospecting the deep lead by means of tunnelling. It will doubtless also be found, as indeed has already proved to be the case at Laurel Hill, that there will be positions where the lead rests on the granite, the decomposition of which has gone on to a sufficient depth to allow of its being sluiced away below the level of the channel, and thus making it possible to work the drift by sluicing, the columnar character of the basalt at the bottom of the flow lending itself readily to removal by the force of the water, because of the amount of decomposition that has gone on along the polygonal joints.

The accompanying geological sketch map shows the denuded edges of the Tertiary basalt, with the drifts, consisting chiefly of sands, cropping out from under it at various places. It will be seen that for a considerable part of its course the basalt still covers the junction between the slates and the granite. So far as is known the granite of this district is not auriferous; that is to say, that gold is not one of its mineral constituents, although gold-bearing reefs occur in the granite in various places. It has been proved undoubtedly that the drift in this Tertiary Deep Lead is auriferous, because in the few positions where it has been worked it was found payable. In the upper part of the lead between the "Sounding Ground" and Bago it is probable that all the gold in the drift must have been derived locally from the denudation of the granite and its contained auriferous reefs. The Pleistocene alluvial deposits in that portion of the valley of Tarcutta Creek, north-west of the the "Sounding Ground," have been extensively worked, and produced considerable quantities of gold. The junction between the granite and the slates passes down this part of the creek for a considerable distance, and it is probable that most of that gold has been derived from reefs and lodes which had occurred in connection with this denuded junction-line, while a certain portion of it may have been derived from the denudation of the upper part of the western arm of the deep lead which passes to the north-west of the "Sounding Ground." It is also likely that gold-bearing reefs and lodes may have occurred along the junction-line now buried under the basalt, and along which the Tertiary valley was eroded, and that their denudation during the excavation of the Tertiary valley may have produced large quantities of gold which was thrown into the drifts now forming the lead south of the "Sounding Ground."

IV.—The Aboriginal Rock-Carvings at the Head of Bantry Bay, Middle Harbour, Port Jackson: By R. ETHERIDGE, Junr., Palæontologist.

[Plate II.]

> **It is very desirable that authentic information should be obtained before it is too late from persons who have long resided amongst the Aboriginals, and have become conversant with their language and peculiarities. (R. B. Smyth, Aborigines of Victoria, 1878, II., p. 232.)**

I.—Introduction.

OF the numerous traces of Aboriginal Rock-Carvings to be seen on the shores of Port Jackson, none probably equal in extent or completeness of detail those on the heights at the head, and on the eastern side of Bantry Bay, Middle Harbour.

The following notes were obtained during a visit to the locality made in company with Mr. G. H. Barrow, of the Australian Museum, when we made carefully measured drawings of the more important figures delineated. Previous to this, however, some years ago, Messrs. Barrow, R. Jenkins, and H. Barnes visited the carvings on behalf of the Australian Museum, and obtained similar drawings, which were afterwards photographed by the latter, and through the kindness of the Curator of the Museum a set of the photographs were supplied for our guidance, and were found of considerable asssistance, although in some matters of detail they are inaccurate. The purely Ethnological aspect of many of these drawings has been treated of by Dr. A. Carroll, in a series of interesting articles in the *Centennial Magazine*,* but so far as I am aware no systematic attempt has been made to describe them in detail. Dr. Carroll's articles are illustrated by wood-cuts, apparently taken from the Museum photographs, as some of them display corresponding inaccuracies of detail.

Similar carvings are not uncommon on many headlands in Port Jackson and on the east coast. A few years ago Sir Charles Nicholson, LL.D., read a Paper before the Anthropological Institute "On some Rock Carvings found in the neighbourhood of Sydney,"† which are very similar to those about to be described. They were discovered by Colonel Vigors during the erection of the battery at Middle Head. "On clearing away the superficial soil and brushwood preparatory to the levelling of the rock, the carvings were brought to light . . . . . . They were covered with several inches of vegetable mould." The carvings consisted of the human form; a whale, upwards of thirty feet long; a jumping kangaroo; fish, and other objects.

II.—Locality of the Carvings.

The carvings are visible on a gently inclined surface or table of Hawkesbury Sandstone on the Public Recreation Reserve [R. 41, 6th Oct., 1879.], immediately at the roadside, leading from the Middle Harbour ferry west of the south-east corner of J. C. Rutter's triangular ten-acre portion, Parish of Manly Cove. The road runs along the summit of the ridge, immediately above the right-hand arm of Bantry Bay, which forms the watershed of the gullies, draining on the east into the Pacific above Manly, and on the west into Bantry Bay.

The table of sandstone over which the carvings are scattered measures two chains in one direction by three in the contrary, and has a gentle slope of seven degrees to the south-west. The high road as now laid out passes over a portion of them. The remains of nineteen carvings are distinctly visible, but there are others partially obliterated, and it is possible that additional ones may be hidden by encroaching low scrub and moss which is fast covering up the face of the table.

III.—Description.

The figures, as in all similar cases which have come under my notice, are represented in their present state, in outline by a continuous indentation or groove from one to one and a half inches broad, by half an inch to one inch in depth. Some are single subjects scattered promiscuously over the surface; others form small groups illustrating compound subjects, but all appear to have been executed about one and the same time.

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* Vol. I., No. 1, p. 53 : No. 2, p. 89 ; No. 3, p. 187.
† Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1880, IX, p. 31.

Dr. Carroll says the figures all point in one direction, facing the rising sun. This, however, is not the case, a fact which is at once proved by some facing east, others north, and some again the west, whilst the general aspect of the table is westerly.

On leaving the road, one of the first objects discernible is represented in Pl. II, Fig. 1, a kangaroo in a horizontal position. The approximate measurements* are a height of five feet five inches by three feet nine inches; but another kangaroo, presumedly on a similar scale, must have been five feet high. This, shown in Pl. II, Fig. 2, was not visible at the time of the visit of Mr. Barrow and myself; but a sketch was obtained on a former occasion by Messrs. Barrow and Barnes. From the flank of the kangaroo a spear is projecting, and this animal is one of the commoner forms depicted in the aboriginal carvings around Port Jackson. The speared kangaroo, according to Dr. Carroll, represents the chief warrior, who employed it as his totemic sign, the spear indicating his death in a similar manner. Figs. 1 and 2 are hardly equal in execution to the cave-drawings in North-west Australia, given by Captain (Sir) G. Grey; but, on the other hand, those of men here depicted are much more proportionately drawn than those accompanying the kangaroos in the work cited.

Approximate to Fig. 1, is the partial figure of a man and an aquatic animal, probably a porpoise (Pl. II, Figs. 3 and 4). The male figure is rather more than five feet in height, the Cetacean being five feet six inches in length and nearly four feet in total width. The representation of the man is much less perfect in outline than are other male figures to be described hereafter. Immediately below, *i.e.*, lower on the sloping sandstone surface, are the outlines of a fish (Pl. II, Fig. 5), and a figure, at first of a somewhat puzzling nature. The general shape of the body and snout-like anterior end suggest the *Echidna* as a fair interpretation. It is about one and a half feet in length (Pl. II, fig. 6).

The next figure which claims our attention, and one of the most interesting of the series is Fig. 7. This object, which can be interpreted in a variety of ways, is fourteen feet long, with a rather undulating outline, a moderately well-formed head, with the eye approximately in position, and a gradually tapering body. It lies parallel with Figs. 5 and 6, but at right angles to Figs. 1 and 3. It possesses neither fins, paddles, or other locomotary appendages. Now, I think this may be supposed to represent either an enlarged figure of an eel, such as the green eel (*Muræna afra*), or a snake, or is it intended to convey an aboriginal idea of the much debated "sea-serpent"? Whatever it may pictorially display, it is certainly one of the most interesting of the series. In close contiguity to these objects is one of those carvings, which Mr. T. W. E. David and the writer have likened to shields, † and lower down the slope of the sandstone table are others.

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* The measurements, although only called approximate, will be found to be substantially correct.

† Rec. Geol. Survey N. S. Wales, 1889, I, pt. 2, p. 143.

The first of these (see as in Pl. II, Fig. 9), situated near the tail of Fig. 7, has a double crossbar in the centre, but no diamond shaped divisions at the apices. In the other two "shields" the cross and longitudinal lines are single, and the diamond shaped divisions at the poles present. The general appearance (Pl. II, Fig. 8) however is again rendered dissimilar by a general diagonal obliquity assumed by the object and much greater convexity of lateral outline. The longitudinal division is also flexuous, whilst in other cases, as Fig. 9, and the figures of those observed at Forty-Baskets Bay[*] the median line is straight and direct. Fig. 9 is itself peculiar in the possession of one divided-off apex, and a double crossbar. As before stated, although possessing but a rough resemblance to the ordinary shield or *mulga*, these objects are regarded by Mr. T. W. E. David and the writer as the representation of shields, whilst Mr. C. S. Wilkinson has suggested that they may be canoes. On the other hand Dr. Carroll explains them as the emblem of a God[†] and also that of fire, or even of the benificient Spirit *Ndewa*, or *Ngungi*. If such is the case, then the existing blacks also use this emblematical ornament to adorn their shields at the present day. The Ethnological Collection of the Australian Museum contains a ***hieleman*** [B. 1788] of hardwood with a longitudinal line in red, and two median horizontal lines, quite resembling those we see depicted in rock carvings[‡]. A Queensland shield in the same collection is similarly ornamented with the addition of a ground work of red dots. I would also point out that the resemblance of these objects to the bullock-hide shields of the Zulu is a marked one. It must be candidly confessed that the size of these objects, one five feet six inches and the other more than six feet in height, is very disproportionate to the measurements of existing aboriginal shields. Fig. 10 is again open to much speculation as to its identity. It certainly is more nearly allied in shape to the shields used by some tribes; but the similarity would have been increased had one cross piece for the hand-hold been present instead of three, wherein it departs wholly from aboriginal shields. The three stretchers would incline one to regard this object as representing a canoe, for although several types of canoe undoubtedly existed amongst the blacks, one form at least was kept rigid and expanded after the manner depicted in the sculpture.[§] It is five feet six inches long.

An advance on the other sculptures existing at this place seems to be made in the originals of Figs. 11*a* and *b* from the fact that an attempt was apparently made to represent a compound idea in the form of a single combat between two warriors. The figures are quite contiguous to one another. The individual seen in Fig. 11*a* seems to be holding in his right hand a body similar to that represented in Fig. 10, and the position in which it is held would lend colour to the belief in its shield-like nature. In the opposite hand are a bundle of rods which have been suggested to be spears, and this explanation for the want of a better may be accepted. On the other hand we are confronted with the fact that these weapons of offence and defence are held in the wrong hands unless the holder be regarded as sinistral; otherwise it must be conceived that the warrior's back is presented to the observer, which is contrary to the other evidence existing in the carving. The opponent (Pl. II, Fig. 11*b*), with legs astride and arms outstretched, much in the position of an aboriginal when throwing the boomerang is equally definitive. I conceive it quite possible that the position of the boomerang, close to the right hand, conveys the idea that this man has just thrown the missile at the subject of Fig. 11*a*, allowing of course for the want of a knowledge of perspective on the part of the aboriginal artist. The ambiguity of the weapons held in the hands of Fig. 11*a* illustrates how difficult it is to arrive at a satisfactory conclusion as to the identity of many of these portrayed subjects; such for instance as Fig. 10. In outline, and the presence of crossbars, this is practically the same as both the above, and it is only the longitudinal lines present in one of the latter, which has given rise to the suggestion that the object portrayed is a bundle of spears.

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[*] Rec. Geol. Survey, N. S. Wales, 1889, t. 21, f, 1-8.

[†] Centen. Mag. I, No. 2, p. 90.

[‡] Compare also the shields figured in Eyre's Journals of Two Expeditions of Discovery into Central Australia, &c., 1845, I (Frontispiece), and Vol. II, t. 3, f. 15. At a meeting of the Linnean Society of N. S. Wales, held on Feb. 25th, 1885, Mr. George Masters exhibited "unusually wide Hielemans" from the Herbert River, Queensland (Proc. Linn. Soc. N. S. Wales, 1885, IX, pt. 1, p. 76).

[§] R. B. Smyth's Aboriginies of Victoria, 1878, I., pp. 408 and 238. Compare the figure of the canoe given in Eyre's Journals of Two Expeditions of Discovery into Central Australia, &c., 1845, Vol. II, t. 4, f. 5.

Other peculiarities may be observed in this and like figures, such as Figs. 3 and 12. In three of these the head is a mere rounded outline, but in Fig. 11*b* it is presented with a rather bird-like appearance.

Another peculiarity is the great angularity given to the knee-cap; this is visible both in Figs. 11*a* and *b*, and Fig. 12. It is further exemplified in the elbow of the left arms of both Figs. 11*a* and *b*. The original of Fig. 11*a* is seven feet high, whilst that of Fig. 11*b* is five feet eight inches; but it has been raised too much on a level with the top of its *vis a vis* for the exigencies of the plate, as the left finger-tips in the carving on the sandstone table are on a level with the waistband of Fig. 11*a*. Dr. Carroll regards these figures as representative of *Biame*, " an ancestral spirit or god." He gives an illustration* which may be intended for this sculpture, and if so, it is very disproportionate.

Fig. 13 is a nondescript animal; it may be a dog, an opinion already advanced by Dr. Carroll, who regards both it and the subject of Fig. 15, as tokens of intermarrying subdivisions of the clan inhabiting the district in which they were carved†.

The fish seen in Fig 14 is one of three following one another in a direct line, and another above the series, with in advance of them, the object sketched in Fig. 15. Those represented by the former figures are all fairly well outlined; but the latter is a very nondescript being. By Dr. Carroll it is regarded as a catfish. There, again, from the continuity of thought displayed by these fish carvings, it seems to me we have a subject—the pursuit of the " catfish"—by the four larger forms. The latter average five feet in length by two feet in width. A portion of this group appears to form the frontispiece to Dr. Carroll's paper; but the single fish is placed below the three in line, instead of above, as here described.

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* Centen. Mag. I, No 1, p. 54.

† *Ibid*, I, No. 3.

The largest and most imposing sculpture in the collection, is the gigantic fish seen in Fig. 16, known to visitors as the "Whale." It is sixteen feet six inches in length, with a greatest width of seven feet through the last pair of fins. It is probably a shark, a fish believed by Dr. Carroll to be a god-emblem amongst the aborigines. This author figures this form with an eye, a feature we did not observe, whilst on the other hand, in his figure, a central dorsal fin is omitted[*] The object projecting from the snout is peculiar, and the only suggestion that the writer can offer is that it may be intended to portray an appendage similar to those surrounding the oral aperture of the Basking Sharks.

Bonwick[†] mentions the carving of a fish on one of the Port Jackson heads, twenty-seven feet in length; and Sadlier[‡] records a gigantic whale, carved near Dawe's Battery. At the head of the "Whale" stands the male figure, Fig. 12, with the arms expanded; but unfortunately it is nearly obliterated, and will soon be indistinguishable. It is five feet seven inches in height, and four feet eight across the stretch of the arms.

A fish differing in appearance and proportions from the preceding figures is seen in Fig. 17, whilst an excellent representation of a boomerang is shown in Fig. 18. The sharp curve recalls to mind the weapon termed by the Victorian blacks *wonguin*.[§] The former may, possibly, Mr. J. Douglas Ogilby thinks, be intended for a bream.

This comprises the principal sculptures so far as they came under our observation. The remainder, although smaller, are equally interesting. Fig. 19 is, I think, without much doubt, a *womerah*, or throwing-stick, with a well-marked socket for the spear-head, and is probably broken off short in the shaft. The two remaining objects are not difficult of interpretation. Fig 20 is a large tomahawk, or hatchet, supposed to be formed of a large pebble. It is about one foot four inches in length, and the head one foot one inch across. A similar example is in the Australian Museum, from Central New South Wales, one foot two inches long, and the head about nine inches in width. The carving may well be compared to a weapon from Lake Tyers, in Gippsland, figured by the late Mr. R. B. Smyth.[‖] In connection with this larger class of weapon, he says:—"The natives of some parts of Victoria had large stone axes, made of basaltic rock, which were used for splitting trees. One in my possession is eight inches in length, five inches in breadth, and two inches in thickness. It weighs 4lb. 8½oz. Implements of this size are very rare."[¶] Fig. 21 is probably a waddy, rather than some form of nulla.[**]

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[*] Centen. Mag. I, No. 1, p. 56. [†] Last of the Tasmanians, 1870, p. 48. [‡] Aborigines of Australia, 1883, p. 17.

[§] R. B. Smyth's Aborigines of Victoria, 1878, I., p. 317, f. 101, p. 315, f. 99f.

[‖] Aborigines of Victoria, 1878, I., p. 366, f. 178.

[¶] *Ibid*, p. 361.

[**] Compare the Kafir *Keerie*, figured by Dr. E. H. Knight, M.A., in his "Study of the Savage Weapons at the Centennial Exhibition, Philadelphia, 1876." Ann. Report Board Regents Smithsonian Inst. for 1879 [1880], p. 216.

IV.—Mode of Production.

Scattered amongst the finished figures are some in an incomplete state, and others just commenced, revealing the method by which the aboriginal artist carved them. A series of shallow disconnected indentations were made on the sandstone surface to the required outline; these were then deepened and widened. The next process was to make similar depressions between those already completed; and these, when deepened and widened also rendered all the depressions confluent, forming a continuous groove representing the outline.

V.—Nature of the Carvings.

The late Mr. R. B. Smyth remarked of the Victorian aborigines, "that they possessed the power of conveying ideas by a sort of picture writing is beyond doubt. Picture writing indeed was common long before Europeans made encroachments in any part of the island-continent. . . . . The native not only was able to convey ideas in this manner, but occasionally made pictures, intelligible to all, representing events in his life."[*] Touching the indications of their presence left by the blacks in Victoria, he adds:—"Even now, as we travel through the country, we find but few indications of a previous race having occupied it. Two of these are the marks cut on trees, which will soon disappear; and the 'native ovens,' or *mirnyongs*."[†] Others described by Mr. Smyth in another part of his work[‡] are stone *miamys* or shelters, circular or otherwise, found throughout Western Victoria. Extending these remarks so as to include vestiges of the aborigines of New South Wales, and to all intents and purposes other parts of Eastern Australia, we may now, with our present knowledge, add to the above three other indications, viz.:—

a. Rock carvings.
b. Rock drawings.
c. Tree carvings.

The remains described in this paper will naturally fall into the first category (*a*),[§] and with others of a similar nature will form a monument to the powers of imitation well known to exist amongst that race, which has been so erroneously placed amongst the lowest of mankind.

VI.—Antiquity of the Carvings.

There naturally arises the question—Are these sculptures the work of the historical blacks, now rapidly dying out? or, are they vestiges of a pre-existing section of the same race? The known natural reticence of the blacks has always rendered the acquisition of reliable information concerning their arts and mysteries a very difficult task. So far close inquiry amongst a number of gentlemen who were intimately connected with the aborigines in the earlier days of colonization has quite failed to ascertain (*a*) that similar carvings have ever been seen in course of production ; and (*b*) that any black known to them had a knowledge of such work in active operation.[*] These facts alone lend a certain amount of antiquity to these remains, although *inter se* they do not appear to indicate a remote date of execution, the subjects delineated being all those with which the later blacks were well acquainted.

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[*] Aborigines of Victoria, 1878, I. p. 286.
[†] *Ibid* II., p. 232. [‡] *Id.* p. 235.
[§] Weapons and other implements, being outside the scope of the present inquiry, are not included here

Drawings absolutely known to have been the work of aboriginals since our occupation of the continent are of quite a different character, and bear evidence of the influence exerted on the mind of the black by his association with the white man. In this sense, compare the picture drawn by "Tommy Barnes," an Aboriginal of the Upper Murray, given by Smyth.[†] The men's heads, pendant coat tails, pipe in mouth, &c., are quite sufficient tests to fix the period of its execution, and the great difference which exists between such drawings, and those works of art represented by the Bantry Bay carvings. In this sense I think they must be looked upon as of a period anterior to the British occupation, and therefore, perhaps representative of an early existing branch of the Australian Black as we now know him. Much the same line of reasoning has been adduced by the late Mr. R. B. Smyth in the case of the gigantic Native Ovens scattered throughout Victoria. The enormous size attained by some was believed by him to indicate their great antiquity, and by analogy that of the builders. Touching the exact period of these sculptures, it is of course impossible to chronologically fix it, but I am quite in accord with Dr. Carroll, who remarks:[‡] "Some must be very old, as the indented lines bear exactly the same appearance as the surface of the rock on which they are made . . . . while chippings made near them, in the same rocks, ninety years ago by surveyors and others look obviously modern by comparision. The carvings must therefore have been made hundreds of years before the first Europeans visited Australia."

Sir Charles Nicholson writes in similar language. He says [§]:—"As to the age of these remains, it is difficult to form any opinion. From the extent of the erosion to which those have been subjected, which have been exposed to the open air, as well as from the depth of the alluvium and size of the trees by which the horizontal carvings are concealed, it is evident that a very considerable interval must have elapsed since the era of their production. The present native race can give no account of these remains."

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[*] Speaking of the paintings which are sometimes met with on the walls of caves in Western Australin, the Rev. C. G. Nicolay says:—"These are supposed to have been made and used by the Boolyas, but some are hunting pieces, and similar designs have been made on the walls of Rottnest Prison by the natives confined there." Notes on the Aborigines of Western Australia. Col. Ind. Exhib., 1886, p. 11. (8vo. London, 1886.)

[†] Aborigines of Victoria, 1878, II, f. 254 (to page p. 257).

[‡] Centen. Mag. I, No. 1, p. 55.

[§] Journ. Anthrop. Inst. Gt. Brit. and Ireland, 1880, IX, p. 32.

VII.—Explanation of the Carvings.

Dr. Carroll assigns to such carvings the importance of being totemic, or tribal emblems, or "symbolical of their tribal myths and laws," each animal or object representing a separate tribe. Thus, the speared kangaroo is the chief warrior; the shields (?) as the emblem of the beneficent spirit *Ndewa*, or *Ngungi*, and also of fire; the male figures represent Baiamai, "an ancestral spirit or God;"[*] the large fish, or shark is a god-emblem, and so on.

The myths and superstitions of the Australian Aborigines have been a source of speculation to all those who have written on them, and no doubt many of these hieroglyphics, if they may be so called, bore peculiar and special reference to some of these. They may even be totemic, although it must not be forgotten that such carvings seem to be more confined to the east-coastal region, within certain limits, than to other parts of Australia. If of this nature, and when found singly, acting as tribal boundary marks, as Dr. Carroll would seem to imply,[†] a serious difficulty presents itself in their indiscriminate distribution around the shores of Port Jackson; and the frequency of any particular totem would render the area occupied by its tribe in some cases remarkably limited. Were it not for this reason, and could the various totemic marks be assigned to their respective tribes, or families within a tribe, they would afford an admirable means of tracing the tribal geographical boundaries, and we might thus in time be able to lay down cartographically the distribution of many tribes, now only remembered in name.

It has also been suggested by Dr. Carroll that when occurring singly such figures may be regarded as tombstones. It is possible such may be the case; but from the fact that the Port Jackson blacks buried in their kitchen-middens and the hearths of their cave-shelters, and so far as known to the writer, not in the proximity of the carvings, this view would appear to be less likely.

I think it more than likely that this formed a portion of a *Bora*-ground, the spot set apart for the performance of the initiatory mysteries attending the entrance of youths into manhood's estate; and so apparently, does Dr. Carroll, from the context of his paper. Dr. J. Fraser[‡] in his interesting account of the *Bora* in the Yūin Tribe, on the south-east coast, mentions that earth-modelled figures are used in addition to carved trees; it may be that in this particular case the stone-carvings take the place of the latter. Against this, however, is the irregular manner in which they are scattered; and on the general question the remarks of Mr. J. F. Mann. This author, in a very interesting paper, "Notes on the

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[*] According to Dr. J. Fraser, B.A., the Kamilaroy Tribe use this name to signify the Creator or Supreme Being. Journ. R. Soc. N.S Wales for 1882 [1883], XVI, p. 207.

[†] Centen. Mag. I, No. 2, p. 91.

[‡] Journ. R. Soc. N. S. Wales for 1885 [1886], XVI. p. 206.

Aborigines of Australia," wherein he figures a number of carvings, states—"No mystery whatever may be attached to these marks. I have seen a young man lying on rock, whilst others traced his outline, and then picked out the line with a tomahawk." [*]

Dr. Carroll traces the origin of the Australian blacks to a mixture of three Asiatic races—"the Papuan, the dwarf Asian negro or Nigrito, and the Indian Dravidian."[†] The Dravidian hunter, says Dr. Carroll, "brought with him his Indian dog—the Australian dingo." Now this opinion has a very strong bearing on the geological history of mankind on this Continent. So far, I believe, I am correct in stating, neither alluvial deposits, nor cave accumulations, with the one exception recorded by the late Mr. Krefft, have yielded the slightest trace not open to question, of man, or his works, in Australia. Cave earth, however, has revealed the presence of the Dingo, or rather the Warrigal, [‡] both in Victoria and New South Wales. Professor M'Coy has shown the presence of its remains in the Gisborne Cave, near Mount Macedon,[§] and the late Mr. Gerard Krefft [||] in the Wellington bone caves. The latter remarks—"There can be no doubt, however, of the presence in this country of a dog during the post-pleiocene period; a few teeth were obtained at Wellington; they resemble the teeth of the common dingo of the present day." If, therefore, such remains are those of the native dog, truly fossil—and accepting Dr. Carroll's statement that this animal arrived with the Dravidian element of the present aboriginal race—it naturally throws the advent of the latter back to Post-Tertiary times. Conclusive geological confirmation of this is at present wanting. Both the late Mr. R. Brough Smyth[¶] and the late Rev. P. MacPherson[**] call attention to the fact that even the stone implements of the aboriginal have not been found either in New South Wales or Victoria in any position, which could be described as other than forming a part of the present historical period. On the other hand, it will be of the utmost importance to receive confirmatory evidence of a paragraph in one of Mr. Krefft's papers, wherein he states:—"I have found the fractured crown of a *human molar* in the same matrix as *Diprotodon* and *Thylacoleo*, at Wellington, in this Colony," for on this, so far as we at present know, will hinge the yes, or no, of man's presence here in Post-Tertiary times.[††]

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[*] Proc. Geogr. Soc. Australasia, N.S.W. and Vict. Branches, 1885, I, p. 51.

[†] Centen. Mag. I, No. I, p. 54. This subject had previously been worked out generally in a very able manner by Dr. J. Fraser, B.A., in his paper "The Aborigines of New South Wales."--Journ. R. Soc. N. S. Wales for 1885 [1886], XVI, p. 193.

[‡] Dingo is the term applied by the blacks to the white man's cur. The native dog is the Warrigal.

[§] Melbourne Exhibition Essays, 1861, p. 168; Geol. Survey Vict. ¼ Sheet 7, N.W., *note*.

[||] Australian Vertebrata, Resent and Fossil, 1871, p. 17.

[¶] Aborigines of Victoria, 1878, I, p. 364.

[**] Journ. R. Soc. N. S. Wales for 1885 (1886), XIX, p. 117.

[††] Geol. Mag., 1874, I, p. 46. (See a Paper by the Writer, read before the Linnean Society of N. S. Wales on 30th April, 1890.)

V.—Note on *Dromornis australis*, Owen: By R. ETHERIDGE, Junr., Palæontologist.

IN dealing with the history of this bird[*] I omitted to mention that the late Mr. Gerard Krefft, in a short paper entitled "Further Discovery of remains of a Great Extinct Wingless Bird," states that he "had already described it" (*i.e.* the femur from the Peak Downs) "in one of our local papers, and proposed for it the name of *Dinornis Owenii*."[†] I am not acquainted with this description, but the medium of publication, even supposing the description to be a full one, forbids the recognition of the name.

Mr. Krefft also referred to bird bones which he had received from Mr. James T. Plunkett, on September 7th, 1873, found in the "Sandhole" Claim, Black Lead, Gulgong, at a depth of one hundred and sixty feet, consisting of "fragments of vertebræ of a bird rather stronger built than the emu, but not larger in size." These may be portions of the same species lately described by Mr. de Vis, as *Dromaius patricius*.

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[*] Rec. Geol. Survey N. S. Wales, 1889, I., pt. 2, p. 126.

[†] Geol. Mag., 1874, I, p. 46., *note*.

EXPLANATION OF PLATE I.

Tryplasma Lonsdalei, *Eth. fil.*

Fig. 1. A few weathered corallites, showing general proportions, arrangement, and union by stolons. Nat.

Fig. 2. A single corallite in vertical section with septa, tabulæ, and a stolon at the upper left hand. x 3.

Fig. 3. Another vertical section, cut distant from one of the walls, with tabulæ, a stolon, and the septa as delicate points. x 3.

Fig. 4. Portion of a decorticated corallite with the supposed pores near the base between the outer ends of the septa. x 2.

Fig. 5. Cross section of a corallite with septa, tabulate area, and stolon. x 4.

Fig. 6. Similar section of another corallite. x 3.

Diphyphyllum Porteri, *Eth. fil.*

Fig. 7. Transverse view of a corallite naturally weathered, showing the inward projection of the septa, and tabulate area. x 4.

Fig. 8. Cross section of two corallites united, showing septa, dissepiments, and tabulate area. x 3.

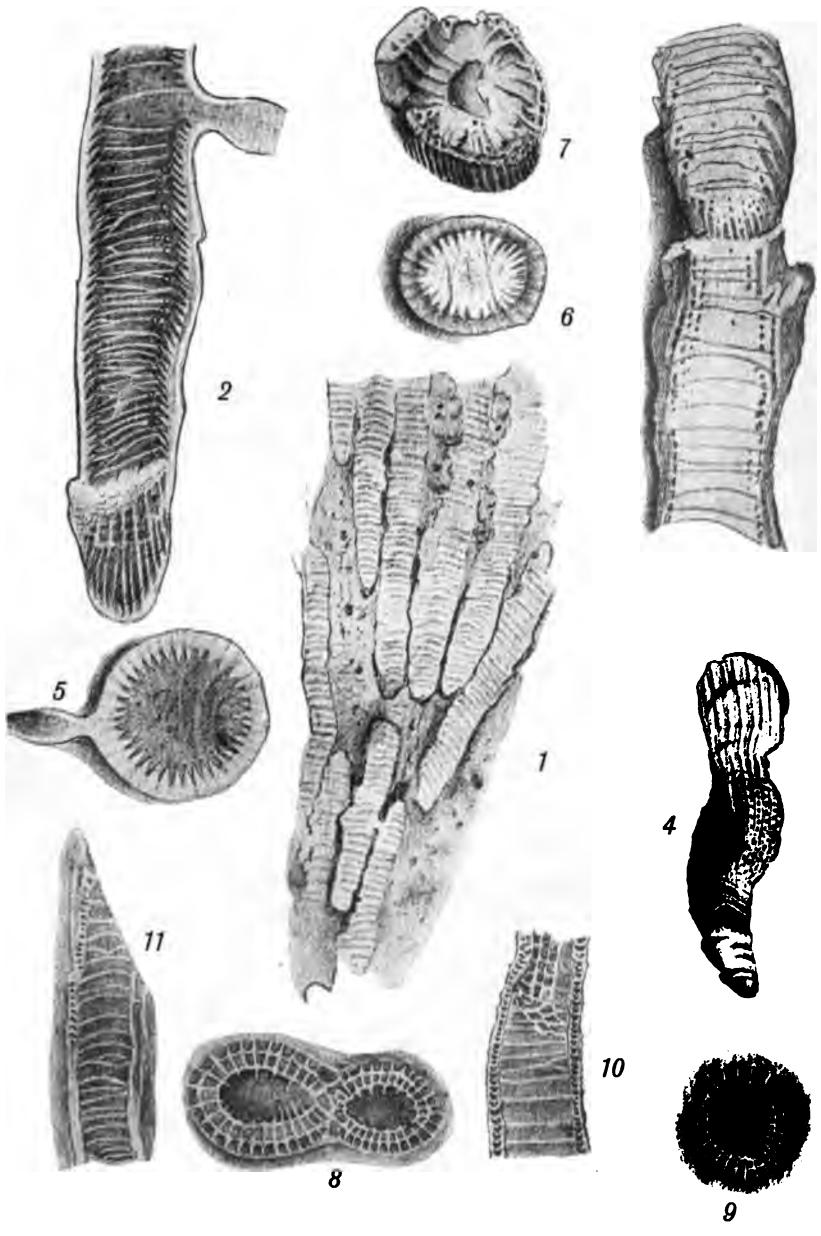
Fig. 9. A similar section of another corallite, from which the proper wall has been removed, with the septa projecting outwards. x 3.

Fig. 10. Vertical section of portion of a corallite with the tabulæ at times vesicular, and the inner ends of some of the septa; a single cycle of dissepiments is shown at the margins. (This figure should be reversed bottom upwards.) x 3.

Fig. 11. Another vertical section with the tabulæ bent down at their circumferences. x 3.

The figures were drawn by Mr. G. H. Barrow, of the Australian Museum.

Plate I.



Reproduced by Heliotype.

EXPLANATION OF PLATE II.

Fig. 1. Kangaroo, which on the sandstone table occupies a horizontal position. 5 feet 5 inches by 3 feet 9 inches.

Fig. 2. Kangaroo speared, probably about 5 feet high.

Fig. 3. Ill-defined figure of a man, without the right arm, rather more than 5 feet high.

Fig. 4. Porpoise, 5 feet 6 inches by 4 feet.

Fig. 5. Small fish, possibly about 3½ feet long.

Fig. 6. Figure of an animal, possibly intended for a "porcupine" (*Echidna*), about 1½ feet in length.

Fig. 7. Probably an eel. It lies parallel with Figs. 5 and 6, but at right angles to Figs. 1 and 3. 14 feet long.

Fig. 8. A shield, hardly bi-laterally symmetrical, with one longitudinal and transverse subdivision, and the apices divided off. Nearly 6½ feet long by about 4 feet wide.

Fig. 9. Another shield, with a double transverse bar, and one pole divided off. 5 feet by 2 feet.

Fig. 10. Canoe. 5 feet 6 inches by 1 foot 6 inches.

Fig. 11. (*a*) Male figure with outstretched arms, apparently holding an object like Fig. 10, and another in the left hand difficult of interpretation. 7 feet high.

(*b*) Another male figure opposite Fig. 11*a*, but slightly lower in position. This seems to represent a man who has just thrown a boomerang. 5 feet 8 inches high.

Fig. 12. Figure of a man with arms outstretched. About 5 feet ¾ inch in height.

Fig. 13. Ill-defined figure of an animal, perhaps a dog.

Fig. 14. Large fish. This is one of four carvings, three following one another in line, and one above the others. Average length, 5 feet; breadth, 2 feet.

Fig. 15. A nondescript figure, termed by Dr. Carroll a "catfish."

Fig. 16. The largest carving of the group, probably intended to represent a shark. 16 feet 6 inches by 7 feet. At the head and in advance of it is placed the male figure, Fig. 3.

Fig. 17. Perhaps intended for a bream, about 3½ feet long by 2 feet wide.

Fig. 18. Boomerang.

Fig. 19. Womerah, or throwing stick, broken short off.

Fig. 20. Large tomahawk, about 1 foot 4 inches in length.

Fig. 21. Possibly a nulla, or waddy.

The figures are drawn by Mr. G. H. Barrow, of the Australian Museum, from measurements made on the ground.

11a

CATALOGUE OF MINING MAPS

PUBLISHED BY THE

DEPARTMENT OF MINES, SYDNEY, NEW SOUTH WALES,

1st JANUARY, 1889.

To be obtained at the Department of Mines, Sydney, and at the Warden's Office in the Mining District in which the land represented on the map or plan is situated.

1s. per sheet is the uniform price.

ALBERT MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Albert	Yancowinna	Thackaringa.	Mount Gipps	Yancowinna	Silverton.
Alma	do	"The Pinnacles."	Moorkaie	do	do Mount Gipps.
Alberta	Farnell	Corona.	Naradin	do	do
Bomangaldy	Yancowinna	Silverton.	Purnamoota	do	do
Bray	do	do	Picton	do	do Broken Hill.
Bolaira	do	Silverton, Round Hill.	Robe	do	do Purnamoota.
Bligh	Farnell	Corona.	Stephen	do	do
Badjerrigarn	do	do	Soudan	do	do
Byjerkerno	do	Poolamacca.	Sebastopol	do	do Rockwell Paddock.
Corona	do	Corona.	Tara	do	do Piesse's Nob.
Edgar	Yancowinna	Silverton.	Umberumberka	do	do
Fowler's Gap (see Giles)	Farnell		Wankeroo	do	do
Giles	do	Fowler's Gap.	Yancowinna	do	do
Lewis	Yancowinna	Silverton.			

BATHURST MINING DISTRICT.

Bolton (a)	Westmoreland	Wiseman's Creek.	Jocelyn	Westmoreland	Wiseman's Creek.
Baring	do		Langdale	do	do
Castleton	Roxburgh	Sunny Corner.	Lennox	Bathurst	Ophir Gold-field.
Coolamigal (b)	do	do	Lewis	do	do
Cullen Bullen	do	do	Mulgunnia	Georgiana	Mulgunnia Gold-field.
Eskdale	do	Clear Creek and Kirkconnell Gold-field.	Oberon	Westmoreland	Oberon Gold-field.
			Tuena	Georgiana	Abercrombie Gold-field.
Falnash	do	Sunny Corner.	Worcester	Bathurst	Ophir Gold-field.
Gillindich	Georgiana	Junction Point, Tuena Creek, and Markdale Gold-fields.	Do	do	do
					(Survey Office litho. adopted.)

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nullama	Gresham	Boyd or Little River Gold-field. (Survey Office litho. adopted.)

HUNTER AND MACLEAY MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bindera	Gloucester	Barrington Gold-field.	Craven	Gloucester	Barrington Gold-field.

LACHLAN MINING DISTRICT.

Bundawarrah	Bland	Temora Gold-field.	Parkes	Ashburnham	Billabong Gold-field.
Currajong	Ashburnham	Billabong Gold-field.	Young	Monteagle	Burrangong Gold-field.

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Gulgong (a)	Phillip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field.
Guntawang (b)	do	do	Wyaldra	Phillip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Arvid	Gough	Vegetable Creek.	Land's End (o)	Gough	Emmaville Gold-field.
Annandale	Clive	do	Muir (p)	do	do
Bundar (a)	Gough	do	Marylands (q)	Buller	Wilson's Downfall.
Bookookoorara (b)	Buller	Wilson's Downfall.	Marsh (r)	do	do
Bates (c)	Clive		Paradise North (s)	Gough	Emmaville Gold-field.
Blain (d)	do		Purvis (u)	Clive	
Bowman (e)	do		Ruby (v)	Buller	Wilson's Downfall.
Binghi (f)	do		Rockvale (w)	Clive	Emmaville Gold-field.
Boorook	Buller	Boorook Gold-field.	Rockglen (x)	do	do
Boonoo Boonoo (g)	do	do	Strathbogie	do	do
Corry (h)	do	Wilson's Downfall.	Strathbogie North (y)	do	do
Cullendore (i)	do	do	Scone	do	do
Cranbrook (j)	Clive	Emmaville Gold-field.	Strachan	do	do
Callanyn	Buller	Red Rock.	Silent Grove (a^1)	do	do
Dumaresq (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
Fraser (l)	do	Emmaville Gold-field.	Undercliff (b^1)	Buller	Wilson's Downfall.
Flagstone	do	do	Wellington Vale	Gough	Emmaville Gold-field.
Highland Home	do	do	Wellington North (c^1)	do	do
Hamilton (m)	do	do	Wylie (d^1)	Buller	Wilson's Downfall.
Haystack (n)	do	Vegetable Creek.	West Fairfield	Drake	

PEEL AND URALLA MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Aston	Hardinge	Cope's Creek.	Hall	Darling	Giant's Den.
Bangheet (a)	Murchison	Bingera Diamond-field.	Hall (k)	Murchison	Bingera Gold-field.
Bingera (b)	do	do	Mayo	Hardinge	Cope's Creek.
Boyd (c)	Gough		Mitchell (l)	Gough	
Bloxsome (d)	do		Macintyre (m)	Murchison	Bingera Gold-field.
Bald Nob (e)	do		Metz	Sandon	Hillgrove.
Clive	do	Cope's Creek	Nundle	Parry	Peel River Gold-field.
Clare	Hardinge	do	Swinton	Hardinge	Cope's Creek
Cope's Creek	do	do	Severn (n)	Gough	
Coventry	Clarke		Scott (o)	do	
Cooney	Sandon	Hillgrove.	Sara (p)	Gresham	Mitchell River.
Darby	Hardinge	Cope's Creek.	Scone and Strathbogie	(See New England Mining District.)	
Dungowan (f)	Parry	Peel River Gold-field.			
Dinoga (g)	Murchison	Bingera Gold-field.			
Derra Derra (h)	do	do Diamond-field.	Tienga	Hardinge	Cope's Creek.
Gouron (i)	do	do do	Worra (q)	Gresham	Mitchell River.
Herbert	Gough	Cope's Creek.	Wood's Reef	Darling	Ironbark Gold-field.
Hanning	Inglis		Wellington Vale	(See New England Mining District.)	
Hall (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nerrimunga	Argyle	Nerrimunga Gold-field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Carroll (a)	Wellington	Hill End and Tambaroora.	Cummings (b)	Wellington	Hill End and Tambaroora.
Tambaroora	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Adelong (a)	Wynyard	Adelong Gold-field.	Ellerslie (e)	Wynyard	Adelong Gold-field.
Bullongong (b)	Murray	Captain's Flat.	Euadera (f)	do	do
Ballallaba (c)	do	do	Gadara (g)	do	do
Calafat (d)	Wynyard	Adelong Gold-field.	Wodalga (h)	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. II, PART II.

1890.

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DEPARTMENT OF MINES, SYDNEY.

RECORDS
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GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. II.] 1890. [Part 2.

VI.—The Raised-beaches of the Hunter River Delta, with Plate III; by T. W. Edgeworth David, B.A., &c., Geological Surveyor, and R. Etheridge, Junr., Palæontologist and Librarian.

[Plate III.]

I.—*Introduction.*

In the present paper it is our intention to describe the Raised-beaches of the Hunter River Delta, more particularly those around Maitland, but before so doing we wish to preface our remarks with a general account of what has been already written on the elevation of the eastern and portions of the southern coast of Australia since the close of the Tertiary Era.

II.—*Other instances of Raised-beaches.*

We have stated later our belief in these shell beds affording evidence of an elevation of the Hunter Estuary. Let us now inquire what further traces there are of similar deposits on other parts of the Australian Coast, north and south.

The late Prof. J. B. Jukes, describes small sandy flats existing at intervals along the north-east coast, wherever he landed during the surveying voyage of H.M.S. "Fly," between Cape Upstart and Sandy Cape. These flats consist of coral conglomerate, "several feet above the reach of any possible tide,"* and strewn with pumice pebbles, but never extending more than fifteen feet above high-water mark. Again, at Lizard Island, pumice was found extending for one or two hundred yards back from the sea.† We cannot do better than quote his general remarks on this coral conglomerate, in the following words:—"It must either have been formed under water, in which case its existence as dry land proves elevation of the whole coast, or it must have been produced by the piling action of the surf heaping up successive accumulations of calcareous sand, which has subsequently compacted into rock. In the latter case, it never could have reached *a higher level* than it now has (a few feet above high-water mark), and its formation by this action must have required an immense period of time, during the whole of which *no depression can have taken place.* Upon all these flat spaces formed of this conglomerate, as well as upon all other flat land along the eastern and north-eastern coast of Australia, which is not more than ten feet above high-water mark, there is found an abundance of pumice pebbles .... They are never or very rarely seen on the present beach, or recently washed up, nor are they now found floating at sea. By whatever cause they were cast upon the land, their present position proves that the whole coast where they are found has been equally stationary, or equally affected by movements of elevation or depression since they were so cast .... That the advent of these pebbles is not a very recent event is proved by facts I observed on the north-east coast. I have picked up pumice pebbles, for instance, on sand and mud flats more than a mile from the sea. If those pebbles were hove up by breakers, there must have been a mile of addditional ground added to the flat since the time when they were so hove. If they were thrown on the land by a sudden wave of great magnitude, this evidence for lapse of time would fail, but that they were not so thrown is, I think, made clear, partly by their equal distribution over the flats, but more especially by their frequently occurring in considerable quantities embedded in the coral conglomerate of which many of the flats are composed. They are also found embedded in the coral rock of Raine's Inlet. Whatever age, therefore, may be given to the coral conglomerates must be extended to the pebbles. Altogether, the evidence derived from the existence of the coral conglomerates, and the presence of pumice pebbles, to a height of eight or ten feet above the highest possible tides, proves, to my mind, that for a very long period the whole eastern coast of Australia has either been quite stationary, or has been affected by slight movements of elevation."[*] Raised beach beds and pumice were observed by Jukes, at Wollongong, and the latter was known to him to occur at intervals along the coast-line for upwards of two thousand miles.[†]

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* Narrative of the Surveying Voyage of H.M.S. "Fly," 1847, I., p. 58.
† Ibid, p. 95.

The pumice question is again referred to by Jukes in his "Physical Structure of Australia,"[‡] but it is to be regretted that the conclusion arrived at by such sound reasoning as the above quotation is abandoned, his mind being apparently influenced by Dr. Darwin's coral reef theory; he, however, remarks—"In the southern part of New South Wales, indeed, and in Tasmania, there are evidences of elevation of the land. . . . . in raised beaches and in beds and accumulations of sea shells beneath the present soil to very considerable altitudes."

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[*] Narrative of the Surveying Voyage of the H.M.S. "Fly," 1847, I., p. 335.

[†] Ibid, p. 336.

[‡] Page 34 (8vo., London, 1850.).

On the Cape Upstart coral conglomerate we likewise have the benefit of Capt. J. Lort Stokes' opinion, who was also well acquainted with Darwin's views. He remarked,—"I will, myself, here adduce what may be deemed an important fact; and which, if allowed its due weight, will go far to weaken the arguments brought forward in favour of subsidence of the N.E. coast of Australia. I found a flat nearly a quarter of a mile broad, in a great sheltered cove, within the Cape, thickly strewn with dead coral and shells, forming, in fact, a perfect bed of them —a raised beach of twelve feet above high water-mark. On the sandy beach fronting it, also a few feet above high water-mark, was a concretion of sand and dead coral, forming a mass about fifty yards long. Fronting this for about the width of one hundred and fifty feet, was a wall of coral, with two feet of water on it, and immediately outside, five fathoms. . . . . Had it been on the seaward side of the cape, I might have been readier to imagine that it could have been thrown up by the sea in its ordinary action, or when suddenly disturbed by an earthquake wave, but, as the contrary is the case, it seemed impossible to come to any other conclusion than that an upheaval had taken place."[*]

Corroborative evidence is to be found in Dr. Alexander Rattray's remarks [†] on the Great Barrier Reef and the islands within it. He says,—"Equally interesting is the evidence that the north-east, if not the whole of the east coast of Australia, is slowly rising, to be found in the gradual shoaling of the channel between Hinchinbrook Island and the mainland (lat. 18½° S.), which is due, to all appearance, neither to silting up nor to the growth of coral . . . . in the shoaling of the inner barrier-reef route and the numerous openings through it, as well as the reef itself, which will one day be out of water, like Raine and other islands." He describes Raine Island as ten feet above high water-mark, and consisting of hard, compact, brecciated coral conglomerate. "It is evident that, though now permanently out of it, it must have been formed well under water, and have reached the surface at low water with the zoophytes which built it in full activity, when the greater part of the long reef now in full activity at the sea level at ebb, and of which it forms only a fractional part, was still many feet below. And now, when the latter has reached close to the surface at low water, the former projects twenty feet in the air."

The Rev. P. N. Wilton long ago stated that the pumice came ashore in the neighbourhood of Newcastle after south-east gales, and in its texture bore a striking resemblance to that abounding on White Island, a more or less active volcano to the north of the East Cape of the north island of New Zealand.[*] On this question the Rev. W. B. Clarke remarked,[†] on the authority of Dr. Dieffenbach, that the pumice could not have come from this locality, but on the contrary he considered it to be very old, "the *débris* of a source long ago erupted." He suggests one or other of the Pacific Islands, such as the Solomons, New Caledonia, Friendly, or Sandwich Islands, or a submarine volcano. Mr. Clarke traced this deposit of pumice in places from the Hunter River to Illawarra, on the north side of bays, such as Bondi Bay and Jervis Bay, but at Red Head, near Newcastle, the deposit lies above high-water mark. The source was believed by Mr. Clarke to be from the north, the pumice being caught by easterly winds and driven accross the current.

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[*] Discoveries in Australia, &c., 1846, I., p. 332.

[†] Notes on the Geology of the Cape York Peninsula, Australia.—*Quart. Journ. Geol. Soc.*, 1869, XXV, p.p. 302-304.

In another place he remarks,[‡] "All along the coast from Torres Straits to Bass' Strait drift pumice may be found wherever there is a lodgment, generally in the north corner of the little shore bays. That this has gone on for ages is apparent, as in one part of the coast, north of Wollongong, there is an accumulation of water-worn pumice some distance from the shore, and beyond the reach of the present waves." Of raised-beaches proper, Mr. Clarke observed that they "occur at various heights on rocky projections of the coast, indicating elevation of the land, of which there is distinct evidence in the recent period, not only in Moreton Bay, but near Sydney, and thence to Bass' Strait; also on both sides of that strait, and as far as Adelaide and King George's Sound."

Equally important remarks were made by Prof. J. D. Dana when writing his Geological Report of the United States Exploring Expedition, under Commodore Charles Wilkes, U.S.N. He states that, "On the eastern coast there are occasional elevated beaches, or deposits of shells, and some appearance of terraces." Prof. Dana further describes a low ridge existing along the coast for most of the way between Bulli and Wollongong, about twenty to twenty-five feet above sea-level, consisting largely of shells, both broken and entire. This bank is at least ten feet above high-water mark, and is clearly regarded by the author as a raised-beach. He also considers that the Illawarra flats, from the foot of the coast range, have been but recently rescued, geologically speaking, from marine action.[§]

As regards the northern coast of the Continent, facts appear to be scanty, although Mr. Fitton gave[||] a good deal of information on the calcareous shore breccias and sand-rocks of that region, which would seem to demonstrate a general upheaval of portions of the coast-line and adjacent regions.

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[*] A Sketch of the Geology of six miles of the South-east Line of the Coast of Newcastle in Australia.—*Phil. Mag.*, 1832, I, p. 95.

[†] On the Occurrence of Atmospheric Deposits of Dust and Ashes, with Remarks on the Drift Pumice of the Coasts of New Holland.—*Tas. Journ. Nat. Sci.*, 1842, I., No. 5, p. 340.

[‡] Sedimentary Formations of New South Wales, 3rd Ed., 1875, pp. 57 and 58; 4th Ed., 1878, pp. 107 and 108.

[§] U.S. Exploring Exped., Vol. X, 1849, Geology, p. 353.

[||] An Account of some Geological Specimens collected by Captain P. P. King, in his Survey of the Coasts of Australia, and by Robert Brown, Esq., on the Shores of the Gulf of Carpenteria, during the Voyage of Captain Flinders.—*P. P. King's Narrative of a Survey of the Inter-tropical and Western Coasts of Australia, 1818-1822*, Vol. II, 1827, *App.* c., *Par.* v., p. 566, Turning more particularly to the south coast we have the late Messrs. Ludwig Becker and J. E. T. Wood's evidence. The first of these writers drew attention[*] to the rising of the shores of Hobson's Bay, Port Phillip, as shown by readings made by Mr. R. L. J. Ellery, of the self-registering tide gauge at Williamstown Observatory, and the appearance of new ground in the bay at points uninfluenced by the deposited matter of the Yarra River. The Rev. Mr. Woods, in his interesting work the "Geology of South Australia,"[†] proves an upheaval to have taken place from King George's Sound to Melbourne by the alteration of coastal lakes from salt to fresh, and the occurrence of marine shells in their banks; the appearance of new reefs of rock along the coast-line, the alterations of soundings, and other features. On this point the first of these authors remarks that since the expedition of Flinders in 1802 a steady rise has been noticeable, for "the soundings of that navigator are rendered useless by the action of subterranean powers." Mr. Becker calculated the rise at about four inches a year.

Count de Strzelecki instances in his "Fourth Period" several cases of "elevated beaches," such as at Lake King, Gippsland; between Cape Liptrap and Portland Bay; Green Island, in Bass' Strait, &c.; but it is possible, and even probable, that these deposits have been relegated to other newer Tertiary formations, rather than retained as portions of those now under consideration.

The observations of the authors just quoted leave little doubt in our minds that a Post-Tertiary elevation of the eastern and southern coasts of Australia actually took place, and the Hunter Valley shell-beds, herein described, offer a strong confirmation of this view. It is also probable that this elevation is to some extent still going on.

Whilst on the subject of the shore pumice it will not be out of place to mention that Prof. A. Liversidge does not find it to actually agree in composition with that of the 1883 eruption of the volcano of Krakatoa,[§] although there is a great resemblance. It is, however, stated by F. D. Bennett in his "Narrative of a Whaling Voyage round the Globe from the years 1830 to 1836, &c.,"[||] that in a strait between the Island of Wageeoo and the Yoel Group, Indian Archipelago, "vast quantities of pumice stone floating in small pieces rounded by attrition" were observed. "Some of them were black, others of an olive-gray colour. . . . Their origin is due to the volcanic islands of this Archipelago: the volcanic mountain of Ternate is often in action; and as late as the year 1836 South-Seamen cruising in the straits of Timor were compelled to keep their decks wet on account of the showers of hot ashes thrown upon them during a volcanic eruption on the Island of Flores. Such collections of pumice stone on the surface of these seas are not uncommon, and are occasionally so great that ships have had their copper brightly polished by passing through them."

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[*] Some Facts determining the Rate of the Upheaval of the South Coast of the Australian Continent.—*Trans. Phil. Inst. Vic.*, 1859, III, p. 7.

[†] Geological Observations in South Australia, 1862, p. 205.

[‡] Phys. Descrip. N. S. Wales, &c., 1845, p. 143.

[§] Journ. R. Soc. N. S. Wales for 1886 [1887], xx, p. 236.

[||] Vol. II, p. 67 (8vo. London, 1840.)

II. Raised-beaches of Maitland.

(A) Definition of terms:—The term "beach", as used by us in this paper, is applied to estuarine deposits which we believe to have been formed *in situ*, in an arm of the ocean, at or below high-water mark. The term "raised" obviously implies that subsequent to their formation they have been elevated more or less above the level of high tide.

(B) Localities:—I. Font Hill, near Farley, West Maitland. The first raised beach in this district, recognised as such, was discovered here by one of the authors in 1886, through information supplied by the late Mr. Peter Green, of Font Hill, several specimens of marine shells, evidently belonging to some comparatively recent geological formation, being found in the spoil-bank at the mouth of an old shaft near there. The shaft being full of water and closely timbered down to the bed rock, it was only by the help rendered by the members of the Maitland Scientific Society that the shell bed was at last reached, and a collection of its shells obtained, most of which are in the Society's Museum in West Maitland.

II. Largs, between East Maitland and Morpeth. Portion of a raised beach was discovered here by Mr. Geological Surveyor Stonier in 1887.

III. Race-course Paddock near East Maitland. A small outlier.

IV. Mr. Hyndes', Regent-street, Campbell's Hill, West Maitland. A small outlier discovered by Mr. J. Waterhouse, M.A., Inspector of Schools.

V. Knott's Well, Bolwarra, near West Maitland. A small outlier.

VI. West Maitland Water-works, Oakhampton Road, West Maitland. Information supplied by Messrs. Walsh and Nicholson, Engineers-in-Charge of the Water-works, shows that an ancient sea-beach exists here where the Oakhampton Road crosses the line of the supply pipe from the Hunter River.

Marine shells have also been met with in part of the same delta deposit in which the Maitland beaches occur, near Mr. Avard's house, at Thornton, and in the alluvial flats below Raymond Terrace. The levels of these latter shells deposits are not yet known.

(C) General Physical and Geological Features:—All the above localities are situated at or near the head of the delta of the Hunter. The district in which this delta lies may perhaps belong to that strip of the coastal area of New South Wales, which Mr. C. S. Wilkinson, F.G.S., has described as having been faulted down in an easterly direction probably during some portion of the Tertiary Era *

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* Mineral Products of New South Wales—Government Printer, Sydney, 1880, p. 70.

This fault, or possibly sharp monoclinal fold, is strongly developed at Lapstone Hill at the first Zigzag near Penrith. It has a general northerly trend, and has thrown down the Lower Mezozoic strata on its eastern side approximately one thousand feet. It is to this dislocation that Mr. Wilkinson attributes the origin of the harbours of Port Jackson and Broken Bay, the faulting down of this area having allowed the waters of the Pacific to ascend some distance up the valleys of the Parramatta and the Hawkesbury Rivers, and so having converted them into estuaries. The boring operations in connection with the placing in position of the iron cylinders, on which the piers of the Hawkesbury Railway Bridge rest, afforded some slight confirmation of this theory. In several places the bores were carried to a depth of over one hundred and twenty feet below the present level of the Hawkesbury River in alluvial beds throughout, and in places at depths of as much as seventy feet below the bed of the river the trunks of large trees were found, bedded horizontally in the silt. This evidence is obviously not conclusive as to the lower alluvial beds here being of fluviatile rather than estuarine origin, as even now during heavy floods in the river, large trees are borne out into deep sea before they become water-logged and sink to the bottom. There is no evidence at present to show whether or not the depression of the coastal area resulting from the Lapstone Hill fault extended as far north as Maitland, as hitherto no unquestionably fluviatile remains have been met with in the deeper portions of the Hunter Delta, unless the thin beds of lignite passed through at Stockton near Newcastle, and in the bore near the old soap works at Long Bridge, West Maitland, are referable to deposits of this kind.

The Hunter Delta is bounded on all sides by low hills few of which exceed five hundred feet in height, composed chiefly of Permo-Carboniferous rocks amongst which those of sedimentary origin locally predominate, though considerable areas on the northern side of the delta are occupied by eruptive and tuffaceous rocks, some of which perhaps belong to the Carboniferous Period. A great unconformity separates the beds of the delta from those of the surrounding formations, the former being Tertiary or Post-Tertiary, while the latter are Permo-Carboniferous or Carboniferous. The delta at its seaward termination, has the shape of a rudely triangular area, the apex of which is prolonged further inland into a number of branches extending a considerable distance up the valleys of the Hunter, Williams, and Paterson Rivers. Along the coast it measures twenty miles in width in a N.E. direction from Newcastle to Port Stephens. Inland it has a general westerly trend following that of the valley of the Hunter River for about a similar distance. The total area is about two hundred square miles. The beds of which it is formed vary in total thickness from a few feet up to two hundred feet, the bottom of the beds where this maximum thickness is attained being about one hundred and eighty feet below sea-level. The surface of the delta is slightly conical, there being a general slope from its head at the

Falls, West Maitland, towards the ocean. The uniformity of this slope is broken at Maitland only by outlying high terraces of ancient flood loam capping The estuarine beds, and to the east of Sandgate and Raymond Terrace by dunes of sand. As the Hunter River is tidal from its mouth up to The Falls, a distance from the ocean—measured in a straight line—of about nineteen miles, it follows that the banks and adjoining flats which are only a few feet above the high-water level at Newcastle gradually increase in height westwards, until at West Maitland they are from thirty to forty feet above the level of high-water mark at Belmore Bridge.

The beds of which the delta is composed are capable of being divided into three different groups, the oldest being placed first:—

1. Sand-rock (half-consolidated sandstone.)

2. (*a*) Ancient estuarine deposits including the raised-beaches.

   (*b*) Ancient flood-loams capping the preceding, and considerably above the level of the highest known modern floods.

   (*c*) Ancient blown-sands perhaps the Æolian equivalents of the raised-beaches.

3. (*a*) Modern flood-loams.

   (*b*) Sand-dunes lately formed, or now in course of formation.

   (*c*) Peat beds forming in swamps on alluvials of delta, and more or less surrounded by the sand-dunes.

   (*d*) Shell-mounds formed by Aborigines.

1. Sand-rock is a fairly hard sandstone horizontally stratified, and varies in thickness from a few up to ten feet. It is developed chiefly on the down-throw side of faults, to the presence of which its preservation appears to be due. No fossils have been found in this formation, and it rests as a rule immediately on the Permo-Carboniferous rocks. Its relation to the raised-beaches is not clear, but it appears to antedate them. It is developed at Eagleton, Thornton, and at the Trigonometrical Station at East Maitland.

2. (*a*) Ancient estuarine deposits including the raised-beaches. By far the greater part of the Hunter delta is probably made up of these beds. They are composed chiefly of sandy clays, stiff bluish-grey clay, sand and gravel, with an occasional layer of lignite and peat. At the bores lately put down at Grahamstown, near Raymond Terrace, and Morna Point, near Port Stephens, these beds were proved to have a thickness of about

one hundred and eighty feet, with a capping of blown-sand about twenty to fifty feet thick. At the former bore (No. 2) marine gasteropodous shells were found in these beds within a few feet of the bed-rock, and at about one hundred and eighty feet below sea-level.

At the No. 1 bore at Grahamstown the following descending section was measured:—

	ft.	in.	
	73	0.	—Drift sand passing into bluish-grey sandy clay.
	77	0.	—Sandy-clay, with a layer of pebbles separating it from the the Permo-Carboniferous bed-rock.
Total,	150	0	

In the same beds in a bore on Tilligerry Creek, a bed of peat, several feet thick, was penetrated at about ninety feet below sea-level.*

At the seventy-two-foot bore at the old Soap Factory, at the Long Bridge, West Maitland, alluvial deposits consisting of gravel, clay, and one thin band of lignite, and probably belonging to this group, were proved to extend to a depth of about thirty-six feet below high tide, and similar beds were proved to have at least as great a thickness at the bores put down before the erection of the flood gates at Wallis' Creek, Victoria Bridge, East Maitland.

(*b*) Ancient flood-loams capping the beds of the preceding group. These are developed chiefly near the head of the Hunter Delta, at West Maitland, and near Paterson. No fossils have as yet been found in them. Their thickness varies from twenty to forty feet, their upper portions being from twenty to thirty feet above the level of the highest recorded modern floods.

(γ) Ancient blown-sands. These are developed chiefly in the sheltered hollows of the Permo-Carboniferous rocks, near Maitland, and in some cases rest immediately on the flood loams. Their thickness varies from a few feet up to ten feet.

3. (*a.*) Modern flood-loams. To this group belong all the black soil areas, inundated by floods, and constituting some of the richest farming land in New South Wales. These beds consist of black loamy-clay, sand and river gravel, and attain a maximum elevation of about thirty feet above high water, there being a surface slope of about eighteen feet in these beds between West Maitland and Hinton, a distance of five and a-half miles. Thickness up to forty feet.

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* This information was supplied us by Mr. D. Watson, of Waratah, one of the holders of the ground upon which this bore was put down at Bank's, on Tilligerry Creek.

(β) Sand-dunes. These are not developed in the neighbourhood of the raised-beaches, and appear to be of later date. They cover the eastern half of the Hunter Delta, between Sandgate and Raymond Terrace, and the ocean to a depth of from a few feet to over fifty feet. The greater portion of this deposit is not drifting now, its surface having become consolidated by the growth of vegetation, many of the trees being probably one hundred years old. Drifting is, at present, confined to a narrow fringe of sand about half a mile wide in places along the coast, between Newcastle and Port Stephens.

(γ) Peat beds formed in swamps occur chiefly in the hollows of the fluviatile beds belonging to the recent flood-loams, or in those of the sand-dune deposit. Small trenches dug by the Aborigines for catching eels are observable in places on the surface of these deposits, especially at the narrow necks by which one swamp is united with another.

(δ) Shell-mounds formed by the Aborigines. These are associated with the sand-dunes between Newcastle and Port Stephens, and are also observable around the shores of Port Stephens, though the largest of them have been destroyed for lime-burning purposes. These shell-mounds at Port Stephens are very similar to those described in the present number of the Records, by our colleague, Mr. Anderson, as occurring at Panbula, and elsewhere along the southern coast of New South Wales.

(D.) Details of the Maitland Raised-beaches. At Largs the following descending section was measured by the authors:—

ft.	in.	
20	0.	—Ancient flood-loam, a dark grey stiff clay.
0	6.	—Loamy-sand with marine shells.
0	9.	—Rusty-brown sand crowded with marine shells.
0	8.	—Ditto with shells tolerably plentiful.
3	0.	—Grey sand without shells.

The flood of 1857 was at this spot 16·66 feet above high water, and the great flood of May, 1890, which rose six feet six inches above the top of this raised beach, was probably here at least eighteen feet above high water, in which case the top of the shell bed would be at least eleven and a-half feet above the same. Aneroid levels make it fifteen feet above high water. The relation of the level of this shell bed to that of the great flood, and to sea level at high water is shown on the upper section of Pl. III.

At Knott's Well, near Bolwarra (See lower section on Pl. III), the following is stated to be the descending section:—

	ft.	in.	
	17	0.	—Blue clay.
	1	0.	—Black sand with fragments of marine shells.
	0	3.	—Sand with abundant marine shells.
	8	0.	—Blue clay.
	2	3.	—Sand, without shells.
Total...	28	6	

The great flood of May, 1890, was about four feet above the top of this well, and is stated to have been here about twenty-nine feet above high water, in which case the top of the shell bed must be about eight feet above high water, a level confirmed by aneroid measurements.

At Font Hill the shell bed was sixteen inches thick, the top of the bed being ten feet seven inches below the surface of the ground. The great flood was here twelve feet above the top of the shell bed. The mean of several aneroid measurements makes the top of this bed about eleven feet above high water. At the Race-course Paddock, near East Maitland, where the back road to Morpeth approaches the culvert from the south along the eastern boundary of the paddock, the following descending section was measured by one of the authors:—

	ft.	in.	
	0	6.	—Black clay, with a few marine shells.
	0	6.	—Bluish and yellowish-gray clay, with a few marine shells.
	1	6.	—Do. crowded with marine shells, *Scapharca gubernaculum* and *Mytilus Menkeanus* largely predominating.
	0	6.	—Do with a few shells.
Total...	2	6	

The level of the top of this shell-bed is from eight to ten feet above high water. It has somewhat the appearance of a Kitchen-midden, but no burnt shells were detected, nor any certain indication of the shells having been gathered together by the agency of the Aborigines.

At Mr. Hyndes' the top of the shell-bed is at least six feet, probably as much as ten feet above high water. A star-fish was found here, associated with shells similar to those at Font Hill.

At the tunnel through which the suction pipe is carried from the Hunter River to the West Maitland Water-works, the top of the shell-bed is about twenty-eight feet below the surface of the alluvial, and about six or seven feet above high water.

(E.) Organic Remains.—The following is a list of the Organic Remains which have been so far determined from the Raised-beach Beds around Maitland:—

	Name of species.	Race-course Paddock.	Hunter River at Largs.	Font Hill.
	Ostrea Angasi, *Sby.*	m.c.	m.c.	m.c.
	Ostrea subtrigona, *Sby.*	v.c.	r.	r.
	Pecten Strangei, *Reeve*	—	v.r.	—
	Pecten asperrimus, *Lamk.*	—	r.	—
5.	Pecten tegula, *Wood*	—	m.r.	r.
	Mytilus hirsutus, *Lamk.*	—	c.	? m.r.
	Mytilus Menkeanus, *Reeve*, var.	v.c.	—	—
	Scapharca gubernaculum, *Reeve*	v.c.	v.c.	r.
	Chama spinosa, *Brod.*	m.r.	—	—
10.	Tellinella deltoidalis, *Lamk.*	—	r.	—
	Corbula scaphoides, *Hindes*	m.c.	c.	—
	Spisula cretacea, *Angas*	—	v.c.	—
	Tapes turgida, *Lamk.*	—	v.r.	—
	Chione isabella, *Gray*	—	v.r.	—
15.	Chione lamellata, *Lamk.*	—	v.r.	—
	Dosinia sculpta, *Hanley*	—	v.r.	—
	Venus (Temoclea), sp.	r.	m.r.	—
	Clementia papyracea, *Gray*	—	v.r.	—
	Fusus Hanleyi, *Angas*	—	r.	—
20.	Nassa livida, *Gray*	—	m.r.	—
	Nassa Jonasi, *Dunker*	—	c.	—
	Natica conica, *Lamk.*	—	m r.	—
	Natica plumbea, *Lamk.*	—	c.	—
	Monilea lentiginosa, *A. Adams*	—	v.c.	—
25.	Calliostoma decorata, *Phil.*	r.	v.c.	—
	Enchelus atratus, *Gmelin*	—	r.	—
	Triton costata, *Born*	—	v.r.	—
	Triton pilæris, *Lamk.*	—	v.r.	—
29.	Risella lutea, *Lamk.*	r.	r.	—
	Lampania australis, *Q. & G.*	r.	r.	—
	Potamides ebeninus, *Lamk.*	m.r.	m.r.	—
	Trochocochlea multicarinata, *Chenu*	r.	—	—
33.	Balanus trigonus, *Darwin*	—	r.	—

r = rare; m.r. = moderately rare; v.r. = very rare; c. = common; m.c. = moderately common; v.c. = very common. These terms simply express the relative degree of occurrence as estimated from the specimens we have seen.

We have had the advantage of studying three collections—a small and original set obtained by Mr. J. Waterhouse, M.A., Inspector of Schools*; another small collection lent by the Maitland Scientific Society; and the much larger series obtained officially under the direction of one of us. The second series was named by Mr. John Brazier, C.M.Z.S., and we are indebted to his intimate knowledge of Australian shells for assistance in the identification of the remainder. The first collection made by Mr. Waterhouse was of particular interest, containing, as it did, some species not met with in either of the others.

It will be at once apparent that the Largs bed is by far the most prolific, with thirty certain, out of the full number of thirty-three species, the absentees being *Mytilus Menkeanus, Chama spinosa, Trochocochlea multicarinata.* Three species on the other hand are exceedingly common at Largs, viz., *Scapharca gubernaculum*,[*] *Spisula cretacea*, and *Calliostoma decorata*. Special attention must be called to the occurrence in this bed of *Pecten Strangei*, *Natica livida*, and *Enchelus atratus*, neither of which are now met with on the New South Wales coast. The former species, of which two specimens were obtained, occurs on the north-east coast of the Continent, and throughout Torres Straits. *N. livida* if found from Moreton Bay round to West Australia; and *E. atratus* is met with in Torres Straits, and around New Caledonia, and the Philippine Islands.

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* Ann. Report Dept. Mines N. S. Wales for 1889 [1890], p. 237

The Race-course Paddock deposit is peculiar from the abundance of *Ostrea subtrigona*, *Mytilus Menkeanus*, *Scapharca gubernaculum*, and *Corbula scaphoides*. The second of these shells is perhaps the most remarkable in the collection, both on account of the numbers in which it occurs, and the fact that it also is not a New South Wales species, but occurs on the coast of South Australia. We were, with Mr. Brazier, mutually so struck with the large size and abundance of *Mytilus Menkeanus*, that a specimen was forwarded to Professor Ralph Tate, F.L.S,, of Adelaide University, for his opinion as to its correct identification. He considers it a rostrate variety of this species. The average size of South Australian examples is from one and a half to two inches in length, but at East Maitland it attains to a length of no less than six and a half inches, by three in breadth.

That a shell otherwise known to occur in South Australian waters, and three others, *Natica livida*, *Enchelus atratus*, and *Pecten Strangei*, elsewhere found in warmer seas, should occur in these Post-Tertiary beds, without inhabitating the coast of New South Wales, is a remarkable fact, and affords an opening for much speculation.

The fauna is essentially a littoral one, and in some respects estuarine also. For instance, *Spisula cretacea*, *Scapharca gubernaculum*, and *Potamides ebeninus*, specially come under the last category, two *S. cretacea*, and *S. gubernaculum* being very plentiful.

Evidence also exists that rather similar raised beach beds occur in Moreton Bay. Mr. R. L. Jack, Government Geologist of Queensland, has sent to one of us fossils from Child's Vineyard, corresponding closely with some of those mentioned above, such as—

Ostrea pestgiris, *Hanley*.
Anomalocardia trapezia, *Desh.*
Potamides ebeninus, *Lamk.*
Natica plumbea, *Lamk.*

The presence of an exotic species in our Post-Tertiary deposits is, however, not unknown, Mr. C. S. Wilkinson having exhibited at a meeting of the Linnean Society of New South Wales, held on 27th May, 1885,[†] a specimen of *Siphonalia*

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[*] Great care is required in determining this species, as apart from *Anomalocardia trapezia*, which it much resembles.

[†] Abstract Proc. Linn. Soc. N. S. Wales, 27th May, 1885, p.v.; Proc. *ibid*, 1885, X, Pt. 2, p. 245.

maxima, Tryon, from the estuarine deposits sunk through at the Stockton, Bullock Island, and Wickham Coal Pits, Newcastle. This univalve was previously known only from the Tasmanian and Victorian coasts, and has not, so far, been observed on the shores of New South Wales by our closest observer, Mr. J. Brazier.

(F.) Agents.—The agents which are now making and modifying this Hunter Delta, are chiefly the fresh waters of the Hunter River, and its tributaries, the Paterson and Williams Rivers—wind, tide, and ocean currents.

The Hunter River and its tributary the Goulburn River together drain an area of 7,320 square miles, the average rainfall over the greater part of it being about fifty inches. During floods, as much as five-sixths of the rainfall for a month are computed to be discharged by the river at the rate of 130,000 cubic feet per second at the head of the delta, at Oakhampton.[*]

The total amount of water passing over the delta, during a great flood, such as that of 1857, is estimated by Mr. E. O. Moriarty, C.E., late Chief Engineer for Harbours and Rivers, to be 88,000 millions of cubic feet.

The quantity of silt brought down by such a vast body of water is necessarily considerable, and the greater part of it is deposited at the upper end of the cone of the delta, near West Maitland, where the river becomes tidal; the fall of its channel for the previous forty-nine miles from Singleton downwards having been at the rate of 2,088 feet per mile.

Sufficient data are not yet available for forming even an approximate calculation of the rate of deposition of this silt. The tide ascends from the present mouth of the Hunter at Newcastle, for a distance of about forty-nine miles measured along the winding course of the river and about nineteen miles in a direct line to the Falls above the Belmore Bridge at West Maitland.

At Morpeth the tidal wave seems to have been lessened somewhat by friction as the level of high-water there is stated[†] to be 1.07 feet below that of high-water at Newcastle. It is improbable therefore that the tidal wave, which travelled up the estuary now occupied by the Hunter Delta, was higher than the tide on the coast, the tides of the raised-beach period being assumed to have risen to the same height on the coasts as modern tides. The fact, however, must be borne in mind that in estuaries such as Lake Macquarie near Newcastle, which communicates by only very narrow outlets with the ocean, and which receive a considerable amount of fresh water drainage, the permanent level of the surface of the water is about that of high tide. As, however, it has been assumed, when calculating the levels given in this paper, that the top of the Maitland Raised-beaches represents the former limit of high tide, the relative levels of these beaches, with regard to the present ocean, would still be the same, even supposing that the sea water in the ancient estuary of the Hunter remained permanently at high tide level.

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[*] Floods in the Hunter. Report of Commission, &c., p. 10 and 101. BY AUTHORITY, Sydney, 1870.
Loc. cit., p. 121.

The tide exercises very little scouring action on the bed of the river, but on the seaward slope of the delta assisted by ocean currents it considerably adds to the delta by carrying large quantities of sand from other parts of the coast and depositing them along the shore between Newcastle and Port Stephens, whence they are blown inland by south-easterly winds towards Raymond Terrace. In view of the loading which the toe of the delta has undergone from this cause, it seems strange that this portion of it has not somewhat subsided.

(G.) Summary.—From the facts above quoted, the history of the formation of the Hunter Delta would seem to have been somewhat as follows:—

At a time, belonging probably to some part of the Tertiary Era, a large estuary, which may have originated partly through the Lapstone Hill fault, occupied the site of the present delta, extending inland from Port Stephens and Newcastle to West Maitland. The Hunter River emptied into this estuary and commenced to form its delta at Oakhampton, the Paterson River did the same at Paterson, and the Williams River at Seaham, the deltas, as usual, formed in the shape of flattened cones, the apex of each pointing up their respective valleys. The estuarine beds were by this process gradually buried under a thickness of from twenty to forty feet of fluviatile material, and ultimately the deltas of the Paterson and Williams become confluent with that of the Hunter, reducing the two first rivers to the positions of tributaries of the last mentioned river.

Subsequently there commenced a gradual elevation of probably the whole delta, in which movement the greater part of the east Australian coast appears to have participated.

This elevation would be most apparent at the upper ends of the delta cones, as these would be not only the highest, but also the oldest portions of the delta, so that they would show the accumulated results of an elevation, which may have been in progress for centuries. On the other hand the beds of the delta nearer the ocean, either from being newer and so having had a smaller share of the elevation, or from having been submerged to some depth below sea-level at the time when the elevation commenced, would be much less likely to show evidence of having undergone a similar movement.

The gradual elevation of the delta compelled the Hunter River and its tributaries to continually deepen their channels, in order to accommodate themselves to the alteration in the level of the land, and so the ancient estuarine beds and their capping of flood-loam near Maitland were constantly being eroded, the redistributed material derived from them contributing to form the present rich alluvial flats within reach of modern floods. The drifting of the sand-dunes inland from the coast, which has had the effect of raising the eastern portion of the delta above sea-level, may have commenced soon after the silting-up of the estuary between Maitland and Raymond Terrace; but the authors believe it to have belonged to a time much later than that, when the raised beaches were being formed. No fragments of pumice have ever been observed in any of the Maitland raised-beaches, nor any traces of man.

(H.) Age.—As regards the probable age of these raised-beaches, although, of course, it cannot be calculated absolutely, some idea as to the necessity for admitting that it must have heen considerable, may be formed from the following proposition:—

The depth of the estuary before the fluviatile deposits commenced to form, being assumed to be thirty feet below the present level of high tide, the highest alluvial terrace being about fifty feet above high-water; time must be allowed in the first case for the accumulation of a total thickness of eighty feet of sediments, which at an assumed rate of deposition of one inch per year, would take nine hundred to one thousand years to form, and probably, at least an equal amount of time must have been occupied in the subsequent erosion of these sediments to a depth of about seventy feet, this work being accomplished partly by the river gradually altering its course so as to undercut the banks of the older river terraces, and partly of fresh-water floods.

Far stronger evidence, however, of the extent of this time is afforded by the changes which have taken place in the distribution of the estuarine molluscan fauna of the east Australian coast. Subsequent to the formation of the Maitland Raised-beaches, as explained in that portion of this paper which treats of their organic contents.

VII.—Notes on the Shell-heaps, or Kitchen-middens accumulated by the Aborigines of the Southern Coastal District; by William Anderson, Geological Surveyor.

[Plates IV—V.]

The district in question embraces the low-lying coastal area east of the Monaro Tableland, between Moruya and the Victorian border. Its coast line is indented by numerous estuaries and salt-water lakes, some of which are of considerable extent, and a few tidal. The seaward outlets of many of them are almost always closed, because of the banking-up of the sand by the action of the waves outside. After heavy rains, however, these sandy obstructions are generally washed away by the large bodies of fresh water which accumulate in the lakes during their passage to the sea.

The littoral portion of this part of the country seems from all accounts to have been permanently inhabited by certain tribes of Aborigines, who occupied specialised areas in the district. Little or no information has been put on record, relative to the manners and customs of these coastal tribes. As in other parts of the Colony, they had particular localities in which they performed certain rites and ceremonies, and in which they buried their dead. One position, on an island near the mouth of the Bodalla River, is known as having been used, even up to very recent times, as a burial-place of the local tribe. Relics of these coastal tribes, which are now nearly extinct (certainly so, as a pure race), are frequently met with over the whole district. These consist of stone weapons and implements, which are often ploughed up in the fields by the settlers ; skeletons laid bare by the action of the sea and creeks ; and artificial accumulations, such as the shell heaps or "Kitchen-middens," which occur so plentifully along the shores of the salt-water lakes. Relics of a more perishable nature, such as the various wooden implements and weapons used by the aborigines, including the boomerang, waddy, &c., and the grass-tree spears, tipped with a short length of hardwood, or barbed with sharp fragments of shells, are rarely met with in any of the recent deposits. The remains of canoes formed of a wide strip of bark have, however, occasionally been exposed on the beach. The two ends of the strip of bark, after having been made pliable by heat, were caught up in plaits, which were held in position by a short wooden pin inserted through them, and permanently fixed by a mass of dried grass-tree gum.

The shell-heaps or "Kitchen-middens," have a wide distribution along the shore-lines of the southern part of the coast. They are, however, chiefly confined to the shores of the innumerable estuaries and salt-water lakes which occur so frequently along the coast, many of which possess a large superficial area, and extend for miles inland. There is hardly one of these coastal indentations whose shores are not studded with shell-heaps, which are now, generally covered with vegetation, some of the trees growing upon them being of considerable size. As a rule the shore-lines are very irregular, consisting of deep bays, sandy spits and rocky promontories. On the shores of the bays, shell-heaps do occur, but they are usually isolated and rare, while in the two latter positions they are exceedingly numerous, individual heaps attaining considerable lateral extent. In every position they are in close relation to high-water mark.

As might be expected the shell-heaps do not always possess a common distinctive form, nor do they occur in positions which were especially selected for their adaptability, except in so far as the contour of the immediate shore-line was favourable for camping ; although from the frequency of their occurrence on the promontories and spits, it would appear as if those positions were often chosen in preference to the more extended shore-lines of the bays, because of their proximity to the habitat of the molluscs which occur more abundantly off these points.

Near their extremities, most of the promontories and spits are very narrow, and of no great height above tide-marks and wherever they have been used by the Aborigines as camping grounds, their whole surfaces are now covered with empty shells, to a variable depth, in places, from a few inches, to four or five feet. On the rocky points the accumulations of shells take no definite shape, being promiscuously scattered over the surface, but on the sandy spits they occur in distinct heaps, sometimes nearly circular in horizontal outline, and often forming long mounds, having a somewhat oval base. Where they occur on the shores of the bays, the heaps are usually flattened, and the shells are more scattered, but this feature may perhaps be due to the effects of denudation subsequent to their formation. They always occur above ordinary high-water mark, although many of them have suffered on their seaward aspects from the denuding action of the high spring tides. Their extent and form seem to have largely depended on the configuration of the shore-line upon which they rested. Where the latter rises steeply and sharply from high-tide mark, the shell heaps upon it do not take the form of mounds, but the whole slope is covered with shells to a variable depth, and sometimes as high as thirty feet up the slope. Wherever the shore-line is flat or only gently sloping, the heaps have a distinctly mound-like shape, but vary greatly in length and height. Their relative size has depended chiefly upon the duration and frequency of the visits, paid by the Aborigines to the individual heaps.

Besides the empty shells, of which the heaps chiefly consist, distinct layers of wood ashes, which vary greatly in thickness and lateral extent, occur distributed through them. They usually form roughly circular patches varying from a few inches up to a foot in thickness. They generally occupy the centres of the more or less circularly-formed heaps of small size, and it would appear from their presence below the centres of such heaps, that the latter had originated around camp fires. In the larger oval mounds, and in those positions where the shells occur scattered over a slope, there are quite a number of distinct ash-layers, of varying thicknesses, and occupying, in relation to each other, different horizontal positions in the heap, although in many cases a section of one of the larger heaps generally shows a series of ash-layers one over the other alternating with layers of shells. These series of ash-layers probably represent distinct periods of visitation, and where they individually attain any great thickness, represent visits of considerable duration, for it is a well-known fact that the Aborigines were never in the habit of making fires of any size, and it would necessarily take a lengthened period for an ash-layer a foot thick to accumulate from these small fires. The presence of the ash-layers to a certain extent, gives an appearance of local stratification to the heaps. The different horizontal positions in which many of them are met with, indicate, that although, upon their return to the heaps accumulated on former visits, the Aborigines sometimes made the fire directly over the old fire-place, still they indifferently placed it on other portions of the heap. The shells upon which the ash-layers immediately rested were in all cases slightly burnt, but this was the only position in which burnt shells were observed to occur. It is, therefore, I think most likely that the edible parts of the molluscs were eaten in a raw state, although it is somewhat difficult to imagine how they were able to extract the soft parts from the numerous large Gasteropods whose shells are so plentiful in the heaps, unless the shells were first heated in the fire, of which however there is no evidence. Some of the larger univalve shells have evidently been broken during the accumulation of the heaps, although the major portion of them are whole, and I think, it is evident from this that these shells were broken for the purpose of extracting the edible part. Many of them, however, were no doubt brought to the camp for the sake of the edible oysters adhering to their outer surfaces. Although the individual shells always lie promiscuously, in relation to each other, there are often local layers which consist almost entirely of specimens of one genus. For instance, it is not at all uncommon to find a layer chiefly consisting of the shells of *Scapharca gubernaculum* in the midst of a thick layer of oyster shells. All the heaps have much the same composition, except that some of them possess certain genera of shells in greater abundance than others. This is no doubt largely due to the comparatively greater abundance of the former genera near the spot where the heaps happen to have been accumulated.

There are only two positions in which I have yet had an opportunity of examining these shell-heaps minutely, on the shores of the estuary of the Wagonga River, which forms the boundary between the Parishes of Wagonga and Noorooma, County of Dampier; and on the Panbula River, between the Parishes of Yowaka and Panbula, County of Auckland. In the former position, on the Wagonga River, with the assistance of Mr. Watson, Schoolmaster at Punkally, two of these heaps were excavated, while a number of the others, which occur on its shores, were partially opened up. Pl. V. shows the positions of the various shell-heaps on Wagonga River, and Pl. IV. those on the Panbula River below the lake.

Wagonga River.—The first heap that was opened was situated on the south bank of the river near the extreme end of Shell Point, the western promontory of Foster's Bay, about a mile from the point where the estuary enters the sea. The name of the promontory is due to the presence of the large quantities of shells which form the various heaps. The largest and best defined heap occurred on the extreme end of the sandy spit which tails off the promontory, and through the centre of this a wide trench was cut. The longer diameter of the heap was in line with the axis of the sand-spit. At the point of the spit the shells, at the lower seaward edge, reached high-water mark, and at these places the heap had been somewhat denuded by the waves. The centre of the heap was five feet in depth, and in cutting through it the section exposed presented three layers of ashes superposed, with layers of shells between. The following is a section giving the approximate thicknesses and mode of occurrence of the various layers:—

	ft.	in.
Surface Soil	0	2
Shells, chiefly *Ostrea Scapharca*, &c.	0	6
Ash layer	1	0
Shells, chiefly *Ostrea*, *Scapharca*, &c.	1	0
Ash layer	0	6
Shells, chiefly *Ostrea*, *Scapharca*, &c.	1	6
Ash layer	0	4
Total thickness... ...	5	0

Besides these centrally placed ash-layers, others were met with in different parts of the heap. The shells immediately below the layers of ashes were always found to be burnt, but those above were never so affected. The most common genera represented in this heap were the species of *Ostrea*, *Scapharca* with *Anomalocardia* and *Potamides*, most of the others being comparatively rare in their occurrence.

The heap contained no vertebrate remains of any great importance. The latter consisted chiefly of fish bones, and in a few places thin layers of fish scales, the result no doubt of the decomposition of pieces of fish skin. A few animal bones also occurred but these were chiefly the remains of small animals, none of them being identifiable. No human remains, nor undoubted implements, nor weapons were met with.

About a quarter of a mile up the Wagonga River, above its junction with Punkally Creek, another large heap was excavated on its right bank. In its general characters it closely resembled that just described at Shell Point. There were, however, a less number of oyster shells and a greater number of specimens of *Scapharca gubernaculum*, the latter form being most abundant in the upper portion of the heap, while the lower part consisted chiefly of species of *Ostrea*, specimens of *Potamides ebeninus* being abundantly distributed throughout. Superficially the heap was very extensive, and over three feet in its deepest part, supporting on its surface trees over a foot in diameter. The great number of ash-layers, some of them of considerable thickness and extent, and the decomposed state of the shells in the lower parts of the heap, would indicate that it was, comparatively speaking, of considerable age. It rested on the sandy beach, and its lower edges were washed by the high tides. In this heap, almost the entire skeleton of a small dog, or dingo was obtained. It occurred at the bottom of the centre of the heap, resting on its left side, on the original surface of the shore on which the heap was accumulated. The skull was complete, and most of the bones of the four limbs were present with a few of the cervical vertebræ, a fractured scapula, and a few fragments of the pelvis. The ribs, and nearly the whole of the vertebral column and pelvis were wanting. Such bones as remained were whole, but so soft and decomposed, that the skull fell to pieces when it was being taken out. The teeth were all present and perfectly preserved. A few rudely shaped fragments of rock, having somewhat sharpened edges, which were, however, not artificially produced, were also met with at various depths. These may possibly have been used as shell-openers. They were generally discoloured, being usually found in close relation to the the ash-layers. Fish bones, jaws and scales, together with the bones of small vertebrates and birds occurred in abundance. Most of the other heaps existing on this river were examined, but not thoroughly excavated. Those occurring on the sandy spit, at the mouth of the Punkally Creek differed from the others by being almost entirely composed of the shells of *Scapharca gubernaculum* and *Potamides ebeninus*, the shells of *Ostrea* being of very rare occurrence.

Panbula River.—The shell-heaps on this river occur chiefly along the shores between Panbula Lake and the sea, although there were one or two heaps on the river banks above the lake, between the latter and the town. I had not an opportunity of examining the shores of the lake itself, where it is probable that numbers exist. Between the lake and the sea they chiefly occur as scattered patches of shells, few having a mound-like shape. This is due to the configuration of the shores which rise steeply on both sides from the river, allowing of the presence of but few bays or flat sandy spits. In appearance, the heaps seem to be very large, but on closer inspection they are found to be of no great depth, although the shells are widely scattered over a large area of the steep banks, even in some cases to a height of over thirty feet. The chief genera represented here are specimens of *Ostrea*, *Mytilus*, *Scapharca*, and *Potamides*. The two species of *Mytilus* are of comparatively rare occurrence in the heaps on Wagonga River. The only vertebrate remains which were obtained, were fish bones and scales, with a few bones of small vertebrates, although I was told that while some of the neighbouring farmers were burning the shells for lime, they repeatedly came upon the remains of human skeletons, and tomahawks, which, however, do not seem to have been preserved.

A list is given below of the species of shells which were obtained during our excavations of the heaps on Wagonga and Panbula Rivers respectively. The specimens were identified by Mr. R. Etheridge, junr., Palæontologist to the Geological Survey, with the kind assistance of Mr. John Brazier, C.M.Z.S.

Name of Species.	Shell Point, Foster's Bay, Wagonga River	South side Panbula River.
Ostrea Angasi, *Sby.*	v.c.	v.c.
Ostrea cuculata, *Born.*	v.c.	v.c.
Ostrea mytiloides, *Lamk.*	m.r.	m.r.
Janira funatus, *Reeve*	r.	r.
5. Pecten tegula, *Wood*	r.	—
Mytilus hirsutus, *Lamk.*	m.r.	m.c.
Mytilus Dunkeri, *Angas*	m.r.	m.c.
Chamostrea albida, *Lamk.*	r.	r.
Scapharca gubernaculum, *Reeve*	v.c.	c.
10. Anomalocardia trapezia, *Desh*	v.c.	—
Rupellaria crenata, *Lamk.*	r.	r.
Chione (Chamelæa) strigosa, *Lamk.*	—	r.
Fusus Hanleyi, *Angas*	r.	r.
Triton Spengleri, *Chem.*	m.c.	m.c.
15. Ranella leucostoma, *Lamk.*	m.r.	m.r.
Natica melastoma, *Sw.*	m.r.	—
Natica plumbea, *Lamk.*	—	m.r.
Natica melanotragus, *Smith*	—	m.r.
Trochocochlea zebra, *Menke.*	m.r.	m.r.
20. Trochocochlea tricarinata, *Chem.*	m.r.	—
Lunella undulata, *Martin*	m.r.	m.r.
Lampania australis, *Q. and G.*	r.	—
Risella nana, *Lamk.*	r.	r.
Calliostoma decorata *Phil.*	m.r.	m.c.
25. Potamides ebeninus, *Lamk.*	v.c.	v.c.
Patella tramoserica, *Martin*	—	m.r.
Patella aculeata, *Reeve*	—	m.r.
Ophicardelus australis, *Q. and G.*	—	r.
Polytropa succincta, *Martin*	—	r.
30. Acmæa alticostata, *Angas*	—	r.
Siphonalia dilatata, *Q. and G.*	—	v.r.
Helix (Discus) funerea, *Cox*	—	v.r.
Total	22	27

v. c. = very common ; c. = common ; m. c. = moderately common ; m. r. = moderately rare ; r. = rare ; v. r. very rare.

Mr. Etheridge supplements this list with the following remarks upon a rare species of Gasteropod which occurred in one of the heaps on Panbula River. "The species detailed in the above lists are such as may still be met with on the coast of New South Wales generally, with the exception of *Siphonalia dilatata*, Q. and G. This is a Tasmanian species, and also occurs on the Victorian coast, Mr. J. Brazier having received an example from Corner Inlet. This is the first record, within my knowledge, of the discovery in a Kitchen-midden of a shell not otherwise known on the New South Wales coast."

In most of the heaps examined, the genus which occurred most frequently comprised the various species of *Ostrea*, and of these, the large mud oyster (*Ostrea cuculata*) was by far the most common. Next in abundance were specimens of *Scapharca* *gubernaculum*, *Anomalocardia trapezia*, and the Gasteropod *Potamides ebeninus*. The heaps occurring on the sandy spit at the mouth of Punkally Creek, however, consisted chiefly of the shells of *Scapharca* and *Anomalocardia*, with *Potamides*, the oyster being by no means common. It was rare indeed to find any specimens of the Gasteropod mentioned above in a fractured or broken condition. In comparing the list of species from the two localities, it will be seen that of the total thirty-two, seventeen were common to both, and these consist chiefly of the larger edible forms. Ten species which occurred in the Panbula heaps were not, so far as my examination went, represented in those of Wagonga River, while the other five species, although present in the latter heaps were absent from the former locality. Many of those species which were not common to both localities, are chiefly small forms which might not have been much sought after as food. The abundance of the two genera *Scapharca* and *Anomalocardia*, in the heaps at the mouth of Punkally Creek, as compared with the rare occurrence of the genus *Ostrea*, which form such a large portion of the other heaps on Wagonga River, may be explained by the fact that the tide does not affect the waters of the Punkally Creek to such an extent as it does the Wagonga River, and consequently the waters of the former creek are a great deal less salt than is the case in the river. The result of this is that the more estuarine forms *Scapharca* and *Anomalocardia* were more abundant off the spit at the mouth of the creek than the oysters were (such is now the case), and the Aborigines who were in the habit of camping there, took the molluscs which they could the more readily obtain.

From various sources I have heard it stated that human remains (skulls and complete skeletons), tomahawks, and other relics of the Aborigines, have from time to time been dug out of some of the heaps on Panbula River, Merimbula Lake, and the shore lines of others of the lakes and estuaries of this part of the coast. In none of the heaps that were excavated during my late visit, did I see any human remains, even an isolated bone, and the only specimens which might possibly have been implements, were some rough fragments of rock with a somewhat sharp edge, not however artificially produced, which may have been used to open or break the shells of the molluscs, for the purpose of getting at the edible portion. One of these possesses a form rudely resembling a tomahawk but having no ground or polished edge. Near the bottom of the heap excavated at Shell Point on the Wagonga River, a flattish pebble of sandstone was met with, having the following dimensions, length seven inches and four-fifths, breadth four inches and nine-tenths, thickness two inches and one-tenth. On both surfaces there are unmistakeable shallow groovings which have undoubtedly been produced by the grinding on them of some implements or weapons, probably tomahawks.

On the steeply-sloping banks of the Panbula River, the empty shells are present up to a height of over thirty feet, and reach down to high-water-mark. It seems curious to imagine that the Aborigines would go to the trouble of carrying the molluscs to such a height, before they ate them, and their presence here rather suggests the possibility of the alteration of level of the coast-line within geologically recent times. This subject is treated of in a paper by my colleagues, Messrs. David and Etheridge, in the present number of the Records. In that paper there is a considerable amount of evidence to show that since Tertiary times (to speak broadly) the relations of the sea and land have not remained permanent along our eastern coast-line. The evidence for a Post-Tertiary elevation of the coast-line is deduced in the paper referred to from a study of the raised beaches, &c., among which no traces of man have yet been found, and it is therefore hypothetical to assume that any elevation has taken place within the human period. While examining the shell-heaps described in this paper the question of a geologically recent raising of the coast-line had suggested itself to my mind, and a few facts which seem to bear upon this subject may be here stated. Very few of the extensive saltwater lakes which occur so numerously along this part of the coast are now permanently open to the sea. If this coast-line had, within recent times, undergone a partial raising, the bottoms of these lakes would also have been raised, and this would lessen the depth of water at their entrances, which would thereby greatly facilitate the silting up of their openings. Again, there are numberless instances along the coast of extensive flats which are now dry land, but which have all the appearance of having been lakes, or estuaries, at no very distant date. As an instance, we have the Tilba Tilba Swamp, at the foot of Mount Dromedary, which has quite evidently been at a very recent period a lake, although there is no human record of the fact. Again, there was, in the early days of the settlement of this part of the Colony by the whites, a tradition among the Aborigines that a few generations back sharks were speared by their ancestors above the bridge which now crosses the Punkally Creek, in a position which is now an extensive marsh land. It is, of course, quite within the range of possibility that in both the instances given, the Tilba Tilba Swamp, and the marshy flat on Punkally Creek might have been silted up by the material carried down by the creeks which flowed through them. Taken in conjunction, however, with these few facts, the presence of the shell-heaps at so considerable a height above the present sea-level would at least indicate that the subject is worth investigating, in this district, to help to establish the fact whether or not there has been an elevation of the coast-line within the human period.

In conclusion, it may be stated that, as the rocks of this district are almost entirely devoid of limestone, which could be utilised by the settlers for building and other purposes, these shell-heaps, with their interesting contents, are gradually disappearing, the mounds being dug into and the shells burnt for the lime that they will produce. Although this is to a certain extent a necessity, it seems to me a great pity that the valuable geological information which they contain should thus, in a very short time, be lost to science.

VIII.—On some beautifully-formed Stone Spear-heads, from Kimberley, North-west Australia; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate VI.]

THE Mining and Geological Museum is indebted to the kindness of Mr. T. H. Nesbitt, of Nowra, for the presentation of the stone Spear-heads represented in Pl. VI, from the Ord River, Kimberley. They were obtained during the surprise of a black's camp by the police, the tribe having had little or no intercourse with white men. The Technological Museum, Melbourne, possesses four other and similar specimens, if anything in a better state of preservation than those here figured. Mr. Rule, of that Institution, informs me that these spear-heads are made by the Leopold Range blacks and bartered to those of the Ord River. The workmanship displayed in the execution of the heads is very remarkable, and will bear comparison with any similar productions of the Palæolithic Period of the Old World, or even those of any savage people at present using stone weapons.

The use of stone spear-heads of the present type amongst the Australian Aborigines appears to be the exception and not the rule, judging from the limited number of recorded instances of their use—in fact, such weapons seem to be almost restricted to the northern coastal region of Australia, extending from Melville Island to Cape York. The late Mr. R. Brough Smyth, in describing* one of a rather different type "from the northern parts of Australia" says—"The head of one is a piece of nearly black basalt, and the others are formed of fragments of yellowish-grey granular quartzite. They are not ground or polished. They are made by striking off chips, and the form of many of them is perfect. Indeed it is scarcely to be believed that skill could be so directed as to produce from pieces of stone, by percussion only, such beautiful weapons. The length of the stone-heads is usually about eight inches. The spears are from nine to nine feet six inches in length, and the shafts are composed of a kind of reed or bamboo. They are securely fastened to the stone-heads by twine and gum."

Such spear-heads are certainly known to be in use as far west as Melville Island, for Dr. E. H. Knight, M.A., figured† three from there, exhibited in the South Australian Court at the Philadelphia Exhibition, in 1876. They are described as from four to six inches in length, and are of three types. One is similar to Smyth's figure, double sharp-edged, and angular in the middle line. The second is similar in shape, with saw-like serrated edges; whilst the third is simply lanceolate, and rather nondescript in character. From Cape York, stone spear-heads are recorded by Dr. J. C. Cox as made of a black, igneous, crystalline stone[*]; and by the late Rear-Admiral P. P. King from Port Essington[†], where they were found to be four inches long, and one and a half inches broad.

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* Aborigines of Victoria, 1878, I, p. 308, f. 85.
† Smithsonian Institution Ann. Report for 1879 [1880], p. 268, f. 87.

That the beautiful spear-heads now figured are from the Kimberley District is to some extent borne out by the remarks of Mr. A. W. Froggatt, who says[‡] that the West Kimberley natives, in addition to the hunting-spear, use the flint-headed spear. The only exception to the restriction of stone-headed spears of this description to the northern districts of Australia is a passage in Governor Eyre's work[§], wherein he says, speaking of the natives of the Great Australian Bight—"They showed us several that were headed with flint, telling us that they procured it to the north-west." Lastly, the use of such spear-heads in the Northern Territory of South Australia is shown by Mr. Inspector P. Foelsche[||], who has ascertained that cicitrization is self-inflicted by both males and females, with a "sharp kind of white flint-stone, the same as is used for spear-heads."

The only previous figure of an Australian spear-head precisely similar to those here depicted is the late Rear-Admiral P. P. King's of a weapon found at Hanover Bay.[¶] His remarks are so highly descriptive that no apology is needed for transcribing them here. He remarks—"But what chiefly attracted our attention was a small bundle of bark, tied up with more than usual care; upon opening it we found it contained several spear-heads, most ingeniously and curiously made of stone; they were about six inches in length, and were terminated by a very sharp point; both edges were serrated in a most surprising way; the serratures were evidently made by a sharp stone with some instrument, but it was effected without leaving the least mark of the blow; the stone was covered with red pigment, and appeared to be a flinty slate. These spear-heads were ready for fixing, and the careful manner in which they were preserved plainly showed their value, for each was separated by strips of bark, and the sharp edges protected by a covering of fur."

The spear-heads in our collection are seven in number—six chalcedonic quartz, and one of bottle-glass. There are two varieties in form—elongately lanceolate, and more or less leaf-shaped, five of the former and two of the latter; but even amongst the first-named there is a variation in outline. All the lanceolate spear-heads are angular in the middle line of one face, and flattened on the other, but one is angular on both faces; on the other hand, the leaf-shaped heads are flattened on both aspects, and it would appear that the broader they become the less angular are they in the middle line. The bi-angular specimen, composed of a much darker chalcedonic quartz than the others, even presents a triangular outline. The extreme points of four of the same specimens are broken, but in those in which the apex is preserved it is sharp and acute. The glass spear-head is truncated at the base; the others are all rounded. Five bear traces of the gum used to hold them in position on the spear, but the remaining two do not appear to have been used.

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[*] Proc. Linn. Soc. N. S. Wales, 1875, I, pt. 1, p. 25.
[†] Intertropical and W. Coasts of Australia, 1827, I, p. 86.
[‡] Proc. Linn. Soc. N. S. Wales, 1888, III, pt. 2, p. 655.
[§] Discoveries in Central Australia, &c., 1845, I, p. 209.
[||] Trans. R. Soc. S. Australia for 1881-82 [1882], V, p.
[¶] Intertropical and W. Coasts of Australia, 1827, II, p. 68, pl. f. 1-3.

The chalcedonic quartz is probably derived from some of the Desert Sandstone beds of the north-central portion of the Continent. In his "Annual Report for 1883," Mr. H. Y. L. Brown describes* the capping of a large district of central South Australia as a "yellow flinty quartzite or porcellanised sandstone," varying in thickness from ten to thirty feet, intensely hard, invariably glazed, and with a conchoidal fracture. It is certainly of Supra-Cretaceous age.

For general purposes of classification, therefore, three types of serrated spear-head may be said to be present, thus:—

1. Elongately lanceolate—angular on one face, flattened on the other.
2. Elongately lanceolate, or almost triangular—angular on both faces.
3. Flattened on both faces.

The following table shows the measurements of the seven specimens:—

No.	Form.	Height.	Breadth.	Thickness.	Substance.	Apex.	Pl. VI.
		in.	in.	in.			
1	Elongately lanceolate—angular on one face.	$3\frac{7}{8}$	$1\frac{3}{8}$	$\frac{5}{16}$	White chalcedonic quartz.	Broken ...	Fig. 1.
2	"	$3\frac{1}{8}$	$1\frac{2}{8}$	$\frac{5}{16}$	Glass...................	Perfect ...	" 2.
3	"	$2\frac{1}{2}$	1	$\frac{5}{16}$	White chalcedonic quartz.	Broken ...	" 3.
4	"	$2\frac{1}{8}$	1	$\frac{4}{16}$	Variegated chalcedonic quartz.	" ...	" 4.
5	Elongately lanceolate — angled on both faces.	2	$\frac{7}{8}$	$\frac{5}{16}$	Brown chalcedonic quartz.	Perfect ...	" 5.
6	Foliolate—flattened on both faces.	$2\frac{1}{2}$	$1\frac{2}{8}$	$\frac{4}{16}$	White chalcedonic quartz.	Truncated	" 6.
7	"	$2\frac{1}{8}$	1	$\frac{4}{16}$	"	Perfect ...	" 7.

The spear-head figured by Rear-Admiral King is nearly twice the size of any of the above. It is of the lanceolate type, and was clearly bi-angular from the section given. The feature, however, which makes it so remarkable a specimen is the exceedingly coarse saw-tooth-like marginal serrations, which must have cost an infinite amount of pains to produce. In the Ord River spear-heads the margins are merely sharply serrated; but in King's figure of the Hanover Bay weapon the place of these simple serrations is taken by more or less square-headed teeth, themselves at times serrated, and separated by interspaces equal to themselves in breadth. Stone implements with a similar saw-like serration of the edges are figured by Mr. E. T. Stevens, from Honduras[*]; and by Mr. John Evans[†], from the Yorkshire Wolds, but under the name of "Saws."

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* South Australia—Ann. Report of the Government Geologist, with plans, &c., 1st August, 1883 (South Australian Parl. Papers, 1883, No. 46), p. 3.

Now, as to the manipulation by which these spear-heads are produced, we find an interesting description by Mr. T. Baines, who accompanied Mr. A. C. Gregory in his 1855–56 Expedition through Northern Australia. Mr. Baines describes the method employed by the Victoria River blacks in the following words[‡]:—"The native having chosen a pebble of agate, flint, or other suitable stone, perhaps as large as an ostrich egg, sits down before a larger block, on which he strikes it so as to detach from the end a piece, leaving a flattened base for his subsequent operations. Then, holding the pebble with its base downwards, he again strikes so as to split off a piece as thin and broad as possible, tapering upward in an oval or leaf-like form, and sharp and thin at the edges. His next object is to strike off another piece nearly similar, so close as to leave a projecting angle on the stone, as sharp, straight, and perpendicular as possible. Then, again taking the pebble carefully in his hand, he aims the decisive blow, which, if he is successful, splits off another piece, with the angle running straight up its centre as a midrib, and the two edges, sharp, clear, and equal, spreading slightly from the base, and again narrowing till they meet the midrib in a keen and taper point. If he has done this well he possesses a perfect weapon, but at least three chips must have been formed in making it." Such an operation would result in the production of pieces roughly shaped like our spear-heads, but the facets and marginal serration are clearly produced by further chipping, for which, undoubtedly, very delicate manipulation is required.

The other forms of stone-armed spears used in Australia known to the writer are two in number. There is the *Mongile*, or as the natives of Lake Tyers call it, *Wal*, consisting of chips of a hard black basalt, or other suitable stone, inserted in a groove along each side of the apex of the spear, and kept in their places by gum.[§] This is termed by Eyre, *Karkuroo*, being barbed in South Australia by flint or quartz.[‖] Both the figures of Smyth and Eyre represent this spear as a most formidable weapon, more especially that of the former. A somewhat conventional figure of this spear is given by Dr. Knight in his "Study of the Savage Weapons at the Centennial Exhibition, Philadelphia, 1876."[¶] This would appear to be the form of stone spear common throughout Southern Australia—at any rate, it exists from the Great Australian Bight, where it was seen in use by Eyre, to the Grampians in Victoria, for Sir T. L. Mitchell mentions[**] such a spear at Mount Aripiles in that range.

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[*] Flint Chips, 1870, p. 289, frontispiece.
[†] Ancient Stone Implements, &c., Gt. Brit., 1872, p. 265, f. 199.
[‡] Journ. Anthrop. Soc., Lond., 1866, IV, p. CIV.
[§] Aborigines of Victoria, 1878, I, p. 304, f. 68.
[‖] Discoveries in Central Australia, 1845, II, p. 306, t. 4, f. 9 and 10.
[¶] Smithsonian Institution Ann. Report for 1879 [1880] p. 266, f. 93.
[**] Three Expeditions into the Interior of Eastern Australia, 1838, II, p. 193.

The second form is only known from a figure by the late Mr. R. B. Smyth.* It is said to come from the " Far North," and consists of greenstone, polished and brought to a point. It is quite unlike any other known form of Australian spear-head.

The third kind of spear is met with in Western Australia, and is called *Gidjee, Gee-jee*, or *Borral.* The head of the spear, says Smyth,† is covered with a hard gum, thicker on one side than the other, and forming a bed in which pieces of stone or glass are implanted.

We have thus in Australia at least four, and perhaps five types of wholly or partially stone-headed spears,—

1. Simple double-edged, lanceolate, three-faced heads, with a more or less entire margin. Melville Island, Port Essington, and Cape York.
2. Double-edged, three-faced, lanceolate heads, with the cutting edges serrated in a greater or less degree. North-west Australia (Kimberley, Ord River, &c.)
3. Wooden spear-heads barbed on both sides with fragments of sharp stone, and called *Karkuroo, Mongile*, or *Wal.* Great Australian Bight to Grampians in Victoria.
4. Wooden spear-heads barbed on one side only, called *Gidjee*, &c. Western Australia.
5. Well-shaped, rounded, and pointed polished heads of greenstone. (Smyth, *Loc. cit.* I, p. 309, f. 87), North Australia (" Far North.")

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* Aborigines of Victoria, 1878, I, p. 309, f. 87.
† Aborigines of Victoria, 1878, I, p. 336, f. 141.

IX.—Notes on the Gunnedah Coal-field; by G. A. STONIER, Geological Surveyor.

I.—Section of Seams I and II, with Analyses of the Coal.

THE first official notice of the Gunnedah Coal-field is to be found in a Report made by Mr. Geological-Surveyor T. W. E. David, B.A., F.G.S., and published in the Annual Report of the Department of Mines for 1886.* The following may be taken as a summary of the more important facts alluded to:—

No. of seam.	No. of portion.	Section of strata and seam.	Analyses.			Remarks.
				Upper portion.	Lower portion.	
I	53 (John Pryor).	50′ basalt. 17′ hard shale passing into strong coal. 6′ 4″ coal-seam. Floor—sandy shale.	Hygroscopic moisture ...	3·00	2·80	Discovered in a well sunk for water on the edge of the flat.
			Volatile hydrocarbons ...	29·50	30·47	
			Fixed carbon	58·80	56·83	
			Ash	8·70	9·90	
				100·00	100·00	
			Specific gravity	1·291	1·278	
			Sulphur	0·61 %	0·52 %	
			Coke...........................	Nil.	66·73 %	
II	16 John Darcey (now J. Melville).	Roof sandstone 4′ 9″ x , coal seam (probably 7′ 0″)	Hygroscopic moisture ...	3·10		Do.
			Volatile hydrocarbons ..	39·60		
			Fixed carbon	48·23		
			Ash	9·07		
				100·00		
			Specific gravity	1·281		
			Sulphur	0·78 %		
			Coke...........................	57·3 %.		

Mr. David remarks (*loc. cit.*) . . . . "It would appear that Darcey's seam is considerably below Pryor's . . . . . The absence of marine fossils at Black Jack, taken into consideration with the fact that here the strata are dipping off beds, which at Somerton, twenty-seven miles to the east, contain marine Carboniferous fossils, favours the supposition that the Gunnedah coal belongs to the East Maitland, or to the Newcastle Series."

The publication of the Report referred to above, attracted speculators and others to the field, and as both properties on which the coal had been found were six miles from the town of Gunnedah, the attention of prospectors was directed to the country nearer the railway line, and this has resulted in the discovery of two seams which are known locally as:—

No. III, M'Cosker's Seam.
No. IV, Curlewis' Seam.

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* 1887, p. 151.

No. III occurs in the ranges behind Pryor's house at Gunnedah.

No. IV was discovered at Curlewis by the Messrs. Poole on land which is now the property of the Centenary Coal and Coke Company, and which is only two miles from the railway. A line to connect the mine with the railway has been almost completed. Its construction has been an easy matter, the gently sloping character of the surface of the ground presenting no engineering difficulties to be overcome. As Curlewis is ten miles nearer to Werris Creek than Gunnedah, the station where the Narrabri and Great Northern lines meet, it is in a more favourable position for the disposal of its coal for the supply of the Great Northern line than any mine yet opened at Gunnedah.

The discovery of both No. III and IV Seams was due entirely to careful prospecting, and when the small thickness of measures exposed is considered, as well as the facts that—

(*a*) The seams have been decomposed for such a distance from the crop, and to such an extent as to permit their floors and roofs almost to touch one another.

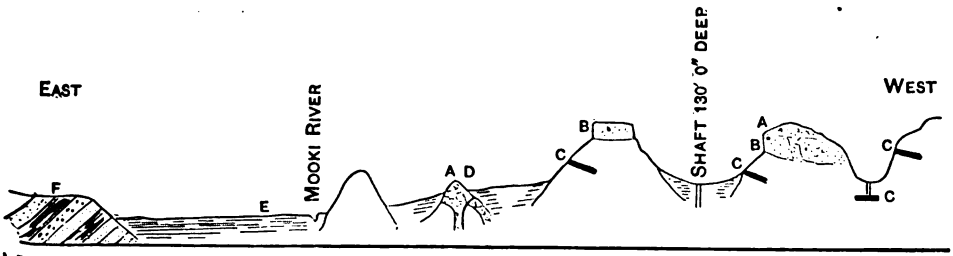
(*b*) Drift blocks of coal, which are such an invaluable assistance when prospecting for the crop of a seam, are never found in the waterways—

it is but little wonder that these fuel deposits have been untouched for so long a time.

Important as was the actual finding of coal in both Darcey's and Pryor's Wells, the section of the beds given by these wells was of little value as a guide for prospecting work in other parts of the district; the strata, too, in the range behind Pryor's house has been much disturbed, and no persistent bed has been noticed which can be taken as a datum line from which to trace out the crops of the seams and to work out the geological structure of the district, so that the prospecting has been necessarily rather haphazard.

At Curlewis, however, a well-marked bed is found in the form of a jasper conglomerate which occurs as a mural precipice, and makes quite a feature in the hill scenery. Its thickness is at least fifty feet, and it can be traced from the company's working tunnel on M.L. 17 for a distance of six miles south-easterly until the hills are lost, and black and red soil country commences, which latter, as shown on the following longitudinal sketch section, extends for some miles further in the same direction.

FIG. 1.



A Basalt. B Jasper conglomerate. C Coal seams. D Red soil. E Black soil. F Devonian (?) sandstones, conglomerates, &c.

From the Curlewis Mine westwards towards Pryor's shaft the country has not been geologically explored, but a bed, which in its occurrence very much resembles the jasper conglomerate, can readily be distinguished in several of the hills between Gunnedah and Curlewis, which are close to the railway. At the Gunnedah coal land, the bed itself has not been noted actually in position, but in a gully near Mr. M'Cosker's Tunnel, several large and loose blocks of it occur. Time, however, did not permit of their being traced to any particular horizon. The hill on which they are found has been much disturbed, and in places quite shattered by intrusive basalt.

The bed has been called jasper conglomerate from the number of jasperoid-quartz and quartzite pebbles from two inches to eight inches in diameter, which are found in it, and render its recognition an easy matter. The pebbles are mostly well rounded, and in addition to the jasper pebbles are quartz pellucid, white and opaque, and altered sandstone with a few quartz porphyry and felspar porphyry pebbles in a greyish-white, sandy matrix. Many of the latter pebbles are coated with ferric-oxide, and on this account those of jasper appear to be in greater quantity than is actually the case.

II.—Sections of Seams III and IV, with Analyses of the Coal.

The following are sections of the Seams Nos. III and IV, together with analyses of the coal. The former have been taken by the author, and the latter made by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines:—

SECTIONS OF THE SEAMS.

No. III, M'Cosker.		No. IV, Curlewis.	
	Roof.		Roof.
Analysis A......	1 ft. 9 in., dull splint coal.	Analysis C......	10 ft., inferior splint coal, with bands.
,, B.....	5 ft. 6 in., splint with thin layers of bright bituminous coal.	,, D.....	1 ft. 6 in., dull splint coal.
	Floor—Bluish-gray clay shale.	,, E.....	4 ft. 6 in., splint with thin layers of bright bituminous coal.
			Floor—Bluish-gray clay shale.

PROXIMATE ANALYSES.

	A	B	C	D	E
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hygroscopic moisture ...	4·36	3·70	3·05	3·10	3·16
Volatile hydrocarbons...	26·52	32·79	19·25	29·40	33·08
Fixed carbon..............	61·47	52·48	48·62	58·47	50·12
Ash	7·65	11·03	29·08	9·03	13·64
	100·00	100·00	100·00	100·00	100·00
Specific gravity...........	1·378	1·365	1·5960	1·404	1·363
Sulphur	1·170	0·617	0·3570	0·357	0·768
Coke	Slightly caked.	63·510	—	67·500	63·76
Ash	Pinkish colour. Dense.	Light-gray Dense.		Light-gray in colour, no copper detected.	Dark-gray in colour. On an examination being made of the ash, a strong trace of copper was detected. The coal was examined by aid of the microscope, and small patches of copper pyrites were plainly visible.

At Curlewis the seams cannot be depended upon for any distance, as they have been proved to pass in places into bituminous shales, with bright black bituminous coal pipes.

It will be noticed on reference to the above analyses that copper pyrites has been detected in sample E. Iron pyrites is noticeable on some of the joint faces of the coal, but for the determination of copper pyrites something more than the unaided eye is necessary. The occurrence of metals other than iron in coal is by no means a recent discovery, for in the year 1851, Daubrée (Percy on Fuel, p. 276) found traces of arsenic and antimony in the coal of Newcastle-on-Tyne, and samples from other localities have been found to contain antimony, arsenic, and copper, and in some British coals galena also occurs. This, however, is believed to be the first recorded occurrence of copper in connection with coal in New South Wales.

III.—*Correlation of the various Seams.*

It would appear from the report of Mr. T. W. E. David, that Seams I and II are distinct, and that No. II underlies No. I, with probably some thickness of strata separating them. At first sight the relation of No. III to either No. I or No. II is not very clear, as the latter are found in shafts on the flat country, while the former occurs in the range, and two hundred and forty feet (actual altitude) above No. I. Owing to the late rains the shafts on the flat could not be examined at the time of the author's visit, but Mr. J. Mackenzie, F.G.S., the Examiner of Coal-fields, has seen the three sections, and verbally states, that he onsiders No. I and No. III to be identical. The dip at Pryor's Well is W. 10° N. at 9½°, and at M'Cosker's Tunnel it is W. 25° S. at 5°, and these two points are about half-a-mile distant in about a meridianal direction, so that the difference in altitude can only be accounted for by a fault, the trend and actual position of which has not, up to the present, been determined.

The analysis of the coal and sections of seams favour Mr. Mackenzie's opinion.

For the elucidation of the question of the relations of the Curlewis to the Gunnedah Seams, there is but slight evidence. The clearest facts are :—

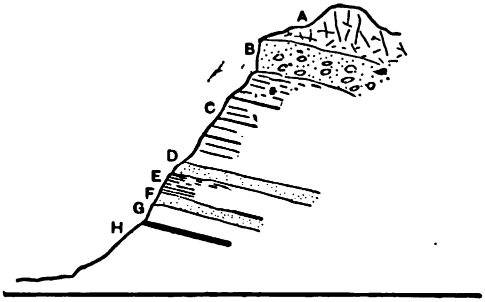
(*a*) Similarity in composition of the Curlewis coal to that of Seams Nos. I and III.

(*b*) Similarity in sections of Seams Nos. I, III, and IV.

(*c*) Similarity in roof and floor of Seams Nos. I, III, and IV.

These facts considered alone would lead to the conclusion that the Curlewis Seam was identical with Seams Nos. I and III, but a comparison of the strata above the seams does not at all favour this view. The lithological difference in the measures is rather decided, for at Curlewis there are two well-marked beds of sandstone, which occur as shown on the following sketch section :—

FIG. 2.



Thicknesses are only approximate.

A	Basalt.
B	50 feet jasper conglomerate.
C	175 feet strata (hidden), probably chiefly sandy-shales.
D	4 feet fine-grained sandstone, cherty in places.
E	45 feet sandy-shales.
F	5 feet quartz grit.
G	40 feet sandy-shales and bituminous shales passing into inferior splint coal.
H	6 feet coal seam.

The thickness between the two sandstone beds, and between them and the jasper conglomerate, varies in places, but the two beds themselves are invariably developed at Curlewis, whereas at Gunnedah there is no sign of either bed, nor, so far as has been observed up to the present, do the strata above the coal at the latter locality appear to bear any resemblance to those overlying the coal at the Curlewis section.

If the Curlewis Seam be not No. I, it is evident from the analyses of the coal, section of the seams, and difference in their respective floors and roofs, that it cannot be No. II Seam; but as loose blocks of the jasper conglomerate, so well developed at Curlewis, are found at Gunnedah, and in about the same position with reference to the coal, it is probable that there may be no very great thickness of strata separating the Curlewis from the Gunnedah Seams.

IV.—*Age of the Measures.*

At Curlewis *Glossopteris* and *Vertebraria* occur in abundance in the Coal-Measures, thus proving them to be Permo-Carboniferous. The latter fossil was observed to be in most cases vertical to the stratification of the beds. No marine fossils have been noticed, nor has any evidence been obtained which will definitely determine the beds as belonging to the Newcastle or to the East Maitland Series, to one of which Mr. David considers the Gunnedah measures to belong.

A Report on the Curlewis District will be published in the Annual Report of the Department of Mines for 1890.

X.—Note on the Occurrence of Fish-remains in the Rocks of the Drummond Range, Central Queensland; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

IN 1882 the late Rev. J. E. T. Woods announced the discovery of plant-remains[*] in the rocks of the Drummond Range, Central Queensland. The fossils were found in sandstone blocks at Bobuntungen, and are ascribed to the age of the Lower Carboniferous. The species determined by Mr. Woods were the following:—

Calamites varians, Germar.
Calamites radiatus, „
Cyclostigma australe, Feistmantel.
Lepidodendron veltheimianum, Sternberg.

To these were subsequently added[†]:—

Neuropteris (allied to *N. gigantea*).
Lepidodendron nothum, (Unger) Carruthers.
Cordaites australis, M'Coy. (?)

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[*] A Fossil Plant Formation in Central Queensland. *Journ. R. Soc. N. S. Wales for* 1882 [1883], XVI, p. 179.

[†] On the Fossil Flora of the Coal Deposits of Australia. *Proc. Linn. Soc. N. S. Wales for* 1880, [1884], VIII, pp. 99, 135, 155.

Mr. Woods considered the beds containing these, as before stated, to be of Lower Carboniferous age, and the equivalents of those at Smith's Creek, near Stroud, and Goonoo Goonoo, near Tamworth, New South Wales.*

Mr. R. L. Jack gives the thickness of the Drummond Range beds at not less than two thousand feet, admirable sections being visible on the Central Railway, between Pine Hills Station and Bobuntungen, the latter being the centre of a synclinal trough.

Some months ago Mr. C. T. Musson, F.L.S., presented to the Mining and Geological Museum numerous pieces of greenish sandy micaceous hard shale, collected by himself, in the Drummond Range, with small fish scales and plates scattered over them. So far as I am aware this is the first discovery of any other organic remains in the Drummond Range series, other than those of plants. It is of importance, notwithstanding the fact that the scales are too indefinite to determine even the genus satisfactorily, as giving weight to the hitherto supposed age of the beds in question. On examining the scales and other plates they struck me at once as those of a Palæoniscid, but before finally adopting this view, I forwarded drawings to Mr. A. S. Woodward, of the British Museum, who confirmed it.

The scales are either inclined to oat-shaped, or rhomboidal, grooved and pitted; some of the grooves anastomosing, others concentrically arranged on the scales. There are also a very few fragments of bone, which, as well as some of the scales, are partially converted into vivianite. The oat-shaped scales are about three-sixteenths of an inch long; the rhomboidal scales two-sixteenths of an inch; and there is a third form, rather inclined to a pentagonal outline, two-sixteenths of an inch long, by a little more than one-sixteenth broad; but modifications of the oat-shaped scale are the commonest.

Mr. Musson has favoured me with the following notes on the locality:—

"On and around a small ridge half-a-mile from, and to the north of the Bogantungan Railway Station, I found numerous fish remains consisting of scales and spines in nodules from what appear to be Carboniferous shales, the beds dipping east, and apparently continuous with those of a similar character developed at the east end of the cutting in the range, some two or three miles away. The fossils occur in nodules, which are seen to rest in thin bands in a section showing hard and soft beds of a peculiar dark-greenish clay (mapped Carboniferous by the Geological Survey), with other harder bands in thin layers, which are sometimes seen to cap the ridges. The fossils were found in situ, and lying about the gullies, of which there are three. The beds rest on a coarse gritty rock in places of a crystalline character. The hard fossiliferous bands vary considerably in themselves, and show evidence of having been altered from their original condition."

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* Journ. R. Soc. N. S. Wales, *loc. cit.* p. 189.

XI.—Description of some Stone Weapons and Implements, used by the Aborigines of New South Wales; by WILLIAM ANDERSON, Geological Surveyor.

RELICS of the Aborigines, who inhabited this Colony, before the advent of Europeans, and who, as a race, are now nearly extinct, are frequently met with during the prosecution of our geological work in various parts of the country, and as these evidences, will, in course of time, be of the utmost scientific interest and value, it is important that a record of them should be kept.

The collections described in this paper consist of stone tomahawks, which were used by the blacks, as offensive weapons and implements; together with a nardoo grinder, and two flat fragments of rock which have been used as portable surfaces on which the cutting edges of tomahawks have been sharpened.

The first ten specimens were given to me some time ago by the Rev. J. Milne Curran, then of Cobar. No. 35 was, however, picked up by myself at the edge of Byrock Water-hole, fifty miles south of Bourke, and No. 36 was found on Yanda Run to the west of Bourke. They had all been used by the Aborigines of the Darling District, and some of them are certainly of local production, as the rocks of which they are made can be readily identified with rocks which occur *in situ* in the district. A number of them have, evidently, been originally well-rounded water-worn pebbles, while the others have been naturally denuded rock fragments which have been picked up by the Aborigines, because of their apparent adaptability for taking a cutting edge, and for use thereafter as an offensive weapon or implement. As a necessary consequence of their original condition as pebbles, and fragments of rock, there is, among them, no uniformity in size or shape; the only general point of resemblance being in the presence of a ground cutting edge. The extent to which the surfaces have been smoothed and polished in the neighbourhood of the cutting edge, varies greatly in the individual specimens, and seems to have depended chiefly upon the texture and hardness of the rock, as well as the amount of painstaking care which was expended in shaping that edge. More labour seems to have been bestowed upon the finer grained and more compact rocks which would be better adapted for taking a high polish, and a true and lasting edge. What smoothing and polishing of the surfaces of the weapon has taken place, has been due, more to the efforts to produce the cutting edge, than to any intentional desire to polish the whole weapon. This I think is evident when we consider the method by which the cutting edge was produced.

All the specimens are longer than they are broad, and this seems to be a characteristic feature of the stone tomahawks used by the Aborigines. In their narrower section they are somewhat flattened, although some are nearly circular or oval. The butt-end of the weapon is never worked, the only portion artificially ground and smoothed being the cutting edge, and varying portions of the faces in its neighbourhood. In most cases an effort has evidently been made to increase the extent of the cutting edge by reducing the length of the pebble, and thus increasing the width of the end to be sharpened. The cutting edge is rarely perfectly straight, but generally possesses a slight curvature in the line of its greatest width. The angle which the smoothed portions of the faces make with each other to form the cutting edge varies considerably, and seems to have depended entirely on the original thickness of the pebble. The ground surfaces containing that angle when thoroughly finished are never flat, but slightly convex; this no doubt, is due to the fact, that in the process of sharpening, the weapon was not held steady, but an undulatory motion was given to it, as it was rubbed in the grooved surface on which the sharpening was accomplished. It is, I think, pretty certain, that, in perfecting the cutting edge of their stone tomahawks the Aborigines endeavoured to obtain an edge, the curved outline of which was distinctive and was a definite factor in their conception of what a perfect weapon should possess. There is great diversity in the degree of perfection to which the individual weapons have been worked. This has been chiefly due, no doubt, to the degree of adaptability which the various rock fragments possessed, of being developed into perfectly-edged weapons, and also to the amount of skill and patience displayed by the individual in manipulating the weapon during the process of grinding. Many of the pebbles have to a certain extent been naturally smoothed by attrition, but most of them present very irregular rough surfaces, and none of them have been artificially chipped, as is the case with the palæolithic stone implements of other countries.

Collection (*a*) may be conveniently divided into two groups, the distinction between them consisting in the difference of character of the original rock fragments, from which the weapons were formed. This division although convenient for the purposes of this paper is by no means arbitrary.

The first group consists of six specimens, Nos. 24, 25, 26, 29, 35, and 36, all of which have undoubtedly been originally well water-worn and rounded pebbles, evidently picked out of some creek-bed. The entire surfaces of No. 36 are highly polished, but this has not been artificially produced, but has been due to natural agencies, as it is quite evident that it was originally a pebble in the conglomerates of Gundabooka Mountain to the west of Bourke. Another peculiarity about this specimen is, that the cutting edge, which is perfect, is nearly straight, thereby differing from all the others of this group in which the edge has a slight curvature. The cutting edge of No. 26 is slightly curved, and is most perfectly finished, the

The following is a tabular view of the dimensions of the various weapons described in this paper:—

	No. of Specimen.		Locality of Rock.	Locality of Specimen.	Greatest diameter.	Greatest breadth.	Greatest thickness.	Extent of cutting edge.	
					in.				
Group I.	24	Leucite basalt ...	El Capitan, 35 miles N.E. of Cobar or Byrock Mt.; 50 miles S. of Bourke.	Cobar District	$3\frac{1}{2}$	2 in. midway between butt and cutting edge.	$1\frac{1}{5}$ in. about middle of weapon.	$1\frac{1}{2}$ in. edge curved	Collection (*a*).
	25	Granite (porphyritic).	....	„ „	$3\frac{4}{5}$	$2\frac{9}{10}$ in. near butt	$1\frac{4}{5}$ in. at butt	$2\frac{7}{10}$ in. „ „	
	26	Fragmental rock	....	„ „	$3\frac{3}{5}$	$1\frac{7}{10}$ in. at butt	$1\frac{4}{5}$ in.	$1\frac{3}{5}$ in. „ „	
	29	Diorite	....	„ „	$3\frac{3}{10}$	$2\frac{3}{10}$ in. cutting edge......	$1\frac{1}{2}$ in. near butt ...	$2\frac{3}{10}$ in. „ „	
	35	Fragmental rock	....	Byrock Waterhole.	$3\frac{3}{10}$	$1\frac{9}{10}$ in. near cutting edge	$1\frac{1}{2}$ in. „ ...	Edge chipped away	
	36	Argillite	Conglomerate, Gundabooka Mt.	Bourke District	$4\frac{3}{5}$	$3\frac{1}{5}$ in. midway between butt and cutting edge.	$1\frac{3}{5}$ in. near one edge of weapon.	$2\frac{3}{5}$ in., edge straight	
Group II.	23	Leucite basalt ...	El Capitan, 35 miles N.E. of Cobar or Byrock Mt.; 50 miles S. of Bourke.	Cobar District	$5\frac{1}{5}$	$3\frac{1}{2}$ in. near base of cutting edge.	$1\frac{2}{5}$ in. near butt ...	Slightly ground on natural curvature of fragment.	
	27	Syenite	....	„ „	$3\frac{7}{10}$	$2\frac{1}{10}$ in. middle of weapon	$1\frac{1}{10}$ in. „ ...	$1\frac{7}{10}$ in.	
	28	Fragmental rock	....	„ „	$3\frac{7}{10}$	$2\frac{3}{5}$ in. near cutting edge	$1\frac{7}{10}$ in. middle of weapon.	$2\frac{2}{5}$ in.	
	30	Diorite	....	„ „	$3\frac{3}{5}$	$2\frac{1}{5}$ in. middle of weapon	$1\frac{1}{5}$ in. „ „	2 in.	
	31	Fragmental rock	....	„ „	$3\frac{3}{5}$	$2\frac{3}{5}$ in. near cutting edge	$0\frac{4}{5}$ in. at butt	$2\frac{1}{5}$ in.	
	32	Basalt	....	„ „	$2\frac{7}{10}$	2 in. middle of weapon...	1 in. middle of weapon.	$1\frac{3}{5}$ in.	
	38	Kiastolite slate...	....	Borolong, New England.	$4\frac{1}{5}$	$3\frac{1}{2}$ in. „ „ ...	$1\frac{3}{5}$ in. „ „	$1\frac{2}{5}$ in.	Collection (*b*).
	39	Volcanic tuff (?)	....	„ „	5	$2\frac{3}{5}$ in. „ „ ...	$1\frac{3}{10}$ in. „ „	Edge not ground...	
	40	Siliceous claystone.	....	„ „	$4\frac{3}{5}$	3 in. „ „ ...	$1\frac{3}{10}$ in. „ „	„ „	
	41	Claystone	....	„ „	$4\frac{9}{10}$	$2\frac{4}{5}$ in. „ „ ...	$1\frac{1}{5}$ in. „ „	$2\frac{1}{10}$ in.	
	42	Aphanite	....	„ „	4	$2\frac{1}{3}$ in. „ „ ...	$0\frac{4}{5}$ in. near butt ...	2 in.	
	43	Basalt (?)	....	„ „	$3\frac{7}{10}$	$2\frac{7}{10}$ in. „ „ ...	1 in. „ ...	$1\frac{1}{10}$ in.	

faces enclosing it being highly polished by artificial means. The same may be said of No. 29. A large fragment has been accidentally chipped out of the cutting edge of No. 35, but whether this has occurred while the weapon was in use, or subsequently, there are no means of determining from the specimen itself. As shown by the measurements given in the table (p. 75), all, with the exception of No. 36, have an oval or rounded section at right angles to their longer diameter.

The second group also comprises six specimens, Nos. 23, 27, 28, 30, 31, 32, all of them having evidently been weathered rock fragments, not showing any decided result of the action of stream-water. They are generally flat, with the exception of No. 28, which is one inch and seven-tenths in thickness. This latter specimen with Nos. 30 and 31 possess well finished cutting edges, the two former being slightly curved and the last nearly straight. The faces enclosing these edges are polished to a variable extent towards the butt of the weapon. The cutting edges of Nos. 23, 27, and 31 are but rudely formed and have undergone but little grinding. The butt end of No. 30 presents a minutely pitted surface, which may possibly have been produced artificially.

I think, it is evident, from a study of this collection of weapons, that there was no endeavour on the part of the Aborigines who formed them to obtain an artistic effect by polishing the whole surface, or by at all shaping the butt end of the weapon. Their chief desire seems to have been to produce a weapon having a perfect cutting edge, although they seem to have exhibited a certain amount of discrimination in picking up the rock specimens from which to form their weapons, showing a preference for such fragments or pebbles, whose shape and hardness appeared to be adapted for producing a weapon which would possess a perfect cutting edge, and would allow of its being conveniently used as such when formed. The polishing of portions of the surfaces was undoubtedly accidental, being due to the method employed in shaping the cutting edge of the weapon.

The second collection of stone weapons consists of six specimens, which were sent to me by Mr. Bloomfield of Borolong, near Armidale, on the New England Table-land.

Five of them differ widely in type from the collection just described from the Darling District, in the fact that they have undoubtedly been artificially chipped into their present form, instead of being merely pebbles or rock fragments sharpened by grinding at one end. The sixth specimen (No. 38) is however a flattish water-worn pebble of kiastolite slate, the narrower end of which has been slightly ground to an edge, which is of very small extent and not at all polished, no effort having been made to chip the pebble into a definite shape. A tomahawk, composed of a similar rock, is mentioned by my colleague Mr. T. W. E. David, in a note, on the rare occurrence of the rock in this Colony.*

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* Proc. Linn. Soc. N. S. Wales, 1887, II., p. 1084.

The other five specimens may be divided into two groups, the former comprising two (Nos. 39 and 40), which are simply chipped, and the latter consisting of three (Nos. 41, 42, 43), which in addition to being chipped possess a ground, but not a polished cutting edge. Taking the first group (Nos. 39 and 40) it is seen that the only work expended on them is the chipping of the edges and greater portions of both faces. In the centres of the chipped faces, however, portions of the original decomposed surfaces of the rock fragments are still visible, showing that they have been formed from rock fragments which were probably picked up and not quarried from a rock mass by the workmen who chipped them into shape. In both cases the entire peripheries of the specimens have been chipped, and it would appear as if their method of procedure had been to work from the edges towards the centres of the faces. The general surfaces and edges, around the butt of the weapon have large flakes chipped off, while the edge which was evidently meant to represent the cutting edge is minutely chipped, particularly on one face of No. 40. An effort has been made to obtain on this specimen a curved cutting edge as near as possible on one plane. The cutting edge of No. 39 is irregular and sinuous, and of the two, No. 40 presents the more finished workmanship. It is uncertain whether these specimens are unfinished weapons, and thereby represent an intermediate stage in the formation of the more perfect forms of the next group, where, in addition to chipping, one end has been ground to a fine edge. I think from our present scant knowledge of the evolution of aboriginal stone-weapons, that this is more likely to be the case, than to suppose that those specimens which are merely chipped were used as finished weapons by the Aborigines of an earlier period than the present, and that therefore they would represent a lower phase of culture in the workman who made them than that possessed by the late Aborigines of the Colony. Additional force is given to this supposition by the fact that in the district in which these weapons were found, there occur quarries to which the Aborigines have been known to resort for the purpose of obtaining rock fragments from which to form their weapons. In and around these quarries numbers of chips and unfinished tomahawks, spoiled in the making, occur abundantly.

The second group differs from the two specimens last described, in the fact that they are not only chipped, but possess a cutting edge at one end, produced by grinding the two faces. The entire surfaces of No. 41 have been chipped, while on one face of No. 43, a small portion of the original decomposed surface of the rock-fragment is left unchipped. The edges only of No. 42, and a small portion of the faces in their neighbourhood have been worked, the larger portion of both faces being untouched. An effort has been made in all three cases to grind a cutting edge at one end of the weapon, and it is evident from the remains of the hollows, left by the flakes, which have not been wholly obliterated in the process of grinding, that the edge was first roughly formed by chipping, and subsequently smoothed. The extent to which the grinding has taken place varies much in the three specimens, and in no case is the ground face polished. The most perfect edge is that produced on No. 41, where a considerable portion of both faces has been ground. One face of No. 42 is more ground than the other, while the cutting edge of No. 43 is of very small extent, and the ground portion of the faces is exceedingly limited. The form of this specimen is somewhat peculiar and unusual, the width of the cutting edge being hardly half the width of the butt of the weapon.

In the formation of these weapons from New England, the various specimens show that they underwent three stages, or processes, in their development into perfect weapons. First, large flakes were chipped off the rock fragments to produce the required form (No. 39), then a series of minute flakes were taken off one end to form roughly the cutting edge (No. 40), and lastly this minutely chipped end was ground to a smooth, sharp, and curved edge.

It is evident, I think, from the rough description that has been given of these two collections, from two widely separated districts of this Colony, that the differences in the methods employed in their formation represent different stages of culture in the workmen who produced them. In the case of the collection from the Darling District, the Aborigines in forming their stone weapons have not exhibited the same degree of culture that is shown by the New England specimens, where the rock fragments have first been chipped into a definite and desired shape before a beginning was made to grind a sharp cutting edge upon them, but they have ground and polished rock fragments, which, to a certain extent, had already been formed by natural agencies into a shape which rudely represented the desirable form. The presence, however, of weapons, formed only by rudely grinding one end of a pebble among those chipped and ground specimens from the New England District would seem to indicate that although the latter was the chief method employed, yet the former was also to a certain extent adopted. Again in those specimens from the Darling District, which have been formed from rough unwater-worn rock fragments, no effort has been made to produce in them a uniform shape, the only work expended on them being in the production by grinding of a cutting edge. It would, therefore, appear to me that we have in the New England specimens a stage of culture, in the formation of their stone weapons, which is midway between, or rather a combination of, the rudely chipped and irregularly shaped weapons of the Aborigines of Tasmania, and the highly polished and perfectly ground tomahawks, possessed by some of the tribes on this continent; and that the evolution of the latter may have taken place in the following order. The most primitive are the rudely chipped rock fragments of no distinctive form (Tasmanian), passing through those which have been chipped into a definite shape (Nos. 39 and 40, New England Collection), into the definitely formed chipped specimens with a rudely ground cutting edge (Nos. 41, 42, 43, New England Collection). Next, the unchipped pebbles and rock fragments, having a more or less distinctive form, not produced artificially, possessing a perfect cutting edge, produced only by grinding, and having the surfaces partially polished; and lastly, those forms, which have the whole surfaces ground and polished, producing a distinctive and uniform shape, and which are the most highly finished weapons of the whole series. Some of these stages were undoubtedly contemporaneous, and they do not therefore represent individual and consecutive human periods.

Most of the tomahawks from the Cobar and Bourke Districts are known to have been in use by the Aborigines of these districts, so that they are of comparatively recent date. The specimens from New England were picked up at various times in the neighbourhood of Borolong, but no evidence can be deduced from the specimens themselves, as to whether or not they are of modern manufacture, although it is very probable that they are.

The three implements, Nos. 33, 34, and 37, may be shortly noticed here:—

Nos. 33 and 34 are flat fragments of sandstone, whose surfaces have evidently been used by the Aborigines upon which to grind the cutting edges of their tomahawks. They have been artificially shaped into their present form in order to make them portable. They were both obtained from the Cobar District of the Great Western Plains. It was the common practice among the Aborigines who frequented these plains to carry such implements with them, because the localities are so few in that flat country, where the outcrops of hard rocks occur, upon which they could grind their weapons, that it was a necessity with them to carry such fragments for the purpose of sharpening their tomahawks. In the mountainous and hilly parts of the Colony numerous places occur where exposed rock surfaces are still to be seen covered with small grooves which have been used for generations by the Aborigines for the purpose of shaping the edges of their weapons.

No. 33 is a fragment of ferruginous sandstone four and a-half inches long, two inches and three-tenths broad, and three-fifths of an inch thick. One of its surfaces is quite flat, while the other is indented by a wide groove which occupies nearly the entire length and breadth of the surface. It is situated nearer to one end of the fragment than to the other, and has been excavated more than half-way through the thickness of the stone. The groove has been produced by the repeated grinding of stone weapons upon the surface of the fragment of sandstone. It is evident that when this implement was in use, the end nearer to which the groove occurs, was held away from the individual while he was employed shaping the edge of the weapon upon it.

No. 34 is a flat fragment of quartzite six inches and one-fifth long, four inches and one-tenth broad, and one inch thick. It has been artificially formed into an irregular oval shape, the edges of which are rough and fractured. One surface is pitted over with minute hollows; the other is perfectly flat and smooth, but is not grooved like the last specimen. On this surface, however, with the aid of a lens, faint striations can be detected traversing it in its longest diameter, and from the presence of these I think it is probable that the specimen has been used for the purpose of putting the finishing touches on the fine cutting edges of their stone weapons.

No 37 is a somewhat flat, nearly circular implement formed of quartzite, which has evidently been used for bruising nardoo seed. It is three inches and four-fifths in greatest diameter, and one inch and two-fifths in greatest thickness. Its thickness around the periphery is nearly uniform, but is not so great as in the centre of the implement. One surface, the lower, is flat and slightly polished, due to the friction produced in bruising the seed between it and another flat surface The upper surface is slightly convex, and has not been produced by artificial mechanical means. Except the slightly polished surface above-mentioned, there is no appearance of the present form of the implement having been produced artificially. It has probably been a pebble picked up, because of its convenient shape, which adapts it to the purpose for which it has been used by the Aborigines.

In concluding this paper I may put on record a locality where a rock surface occurs, such as that mentioned above as having been used by the Aborigines for grinding their stone weapons.

While travelling with Mr. Lowe, of Wilbertree, from Home Rule, in the Mudgee District, to the Talbragar River, to visit a deposit containing fossil fish, that gentleman showed me the rock-surface in question. It occurs on the right bank of the Cockabutta Creek, in the Parish of Bobada, County of Bligh. The district consists of extensive outliers of Hawkesbury Sandstone, which locally overlie no great thickness of portion of the Permo-Carboniferous Series, while there are local areas where the older Palæozoic formations crop out through both these newer formations. The Cockabutta Creek, however, at the locality I mention, has merely worn its channel into the Hawkesbury Sandstone, which at this particular spot is exposed for a considerable distance along its banks. There was little or no water in the creek at the time of our visit, which was during the drought of 1888. The sandstone is by no means fine-grained, for in places it is gritty and full of pebbles. Its weathered surface rises gently from the creek-bed, and, for about twenty yards along the banks this surface is dotted over with hundreds of grooves from an inch to an inch and a half in depth and of variable length. About twenty feet higher up the bank another flattish surface of sandstone is exposed, and this presented the same appearance, being hollowed out in innumerable grooves similar to the others, and undoubtedly produced by the Aborgines while grinding an edge on their tomahawks. A number of chips of a hard rock were picked up around these ground surfaces, and these were certainly not obtained from any rock mass in the immediate neighbourhood, but were probably brought from a distance. It is evident that this locality was a favourite camping-ground of some tribe of Aborigines (probably local), and from the enormous number of grooves present on the rock surfaces, the place must have been visited very frequently. Some of the grooves seemed a great deal more recent than others. The groovings on the higher surface having every appearance of being much older than those near the present creek. It is just possible that the difference of the level between the two sets of grooves may represent the time taken by the creek to erode its channel from the one level to the other, for, according to the reported methods of procedure, the Aborigines did not use a rock surface for the purpose referred to, unless it was in close relation to the water. It was stated to me that the method pursued was as follows:—The water was laved from the creek, generally by the gins, on to the rock surface where the sharpening was to take place, and for this reason these surfaces were always chosen close to the water. It might be suggested that the higher groovings may have been produced at times when the creek was flooded up to that level, but the large number of the grooves in that position is against this idea, because the creek does not drain any large area of country, and, consequently, when in flood would certainly not take more than a few hours to subside. It is probable that some of these grooves are of considerable age, as it is evident that these rock surfaces have been used for a very long time.

XII.—Descriptions of Two undescribed Univalves from the Carboniferous Rocks of New South Wales; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

IN the Annual Report of this Department for 1889,[*] I gave a list of fossils collected by the Rev. W. H. H. Yarrington, M.A., at Torryburn, a new locality about twelve miles from Paterson, Co. Paterson. The organic remains in question indicate a well-marked horizon in our so-called Lower Carboniferous rocks, and bear a stronger relation to the European Carboniferous Limestone than any I have yet examined from Eastern Australia. Since Mr. Yarrington's collection was made we have been favoured with a second series by Mr. John Waterhouse, M.A., and I am in consequence able to afford a more satisfactory determination of certain species than formerly, and describe two of the Univalves, which are certainly undescribed so far as Australia is concerned.

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[*] Ann. Mus. Hist. Nat. Belgique, 1883, VIII.

The additional species to be added to the list are *Orthotetes crenistria*, Phill, *Strophomena analoga*, Phill., *Productus giganteus*, Martin, of the form called *P. maximus* by M'Coy, and a small *Conularia.*

The species to be described both belong to the Pleurotomariidæ, and to genera new to Australia, viz., *Gosseletia*, and *Baylea.*

Genus Gosseletia, *de Koninck*, 1883.

(Faune Calc. Carb. Belgique, pt. 4, p. 28.)*

Gosseletia australis, *Eth. fil.*

Sp. Char.—Shell sub-globular, heliciform, composed of six, or perhaps seven, convex whorls; spire short, and somewhat depressed; suture moderately apparent, without being deep; body-whorl more than double the height of the remainder of the shell, regularly convex and in no way angular; band very apparent, straight, convex, and prominent, placed at about one-third the height of the whorl from the suture, and not on the greatest periphery, defined by two bounding grooves, both of which appear equally well marked, the lower being the continuation of the suture; base somewhat flattened; callosity large, irregularly semi-lunar, and bounded by a shallow groove; apperture unknown; surface, apparently smooth.

Obs.—I was first made acquainted with this interesting addition to our Carboniferous Fauna by a single example presented by Mr. H. Copeland, M.L.A., from the Isis River, Murrurundi. It is very closely allied to the Belgian Carboniferous Limestone shell *Gosseletia callosa*, De Kon,* the type of the genus. Our shell, however, differs in being a much larger species, the prominence and convexity of the band, besides other general features. We possess the species in all ages, from the young state to maturity.

Genus Baylea, *de Koninck*, 1883.

(Faune Calc. Carb. Belgique, pt. 4, p. 68).

Baylea Koninckii, *Eth. fil.*

Sp. Char.—Shell irregularly turriculated, gradiform, of about six very angula whorls, concave on the sides, horizontal or slightly concave on the upper surfac the angle formed by the union of the two surfaces being rather more than a righ angle, occupied by the band, and forming the greatest periphery of the shell band of medium width, limited on its inner edge by a prominent keel; base convex, separated from the concave side of the body whorl by the first of the spiral ridges ornamenting it; the upper surface and side of each whorl ornamented by from two to three fine spiral ridges; mouth and umbilicus unknown.

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* Faune Calc. Carb. Belgique, pt. 4, p. 28, t. 23, f. 13-16.

Obs.—This species first came under my notice from a N. S. Wales locality in Mr. Yarrington's collection, and other specimens were subsequently forwarded by Mr. Waterhouse. It is obviously near *Baylea Leveillei*, De Kon.,* but is much more turriculated, whilst the marked subdivision of the body-whorl into two areas, distinctly separates our shell from the Belgian. The very turriculated outline would also place *B. Koninckii* near *B. Yvani*, Lev., but there are no other specific characters in common.

In certain Queensland univalves forwarded to me from the Rockhampton District, by Mr. C. W. de Vis, M.A., Curator of the Queensland Museum, which I think may be this species, the concave sides of the body whorls are much less marked, but become apparent in the casts. At present I believe them to be the same species.

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* *Loc. cit.* p. 73, t. 27, f. 6-10.

PLATE III.

Fig. 1. Horizontal section of Raised-beach beds at Largs, near East Maitland.

Pleistocene { 1. Raised-beach.
2. Ancient flood-loam capping preceding.

Recent...... { 3*a*. Recent dark-grey clay.
3*b*. Recent sandy-clay and loam.

Fig. 2. Horizontal section of Raised-beach beds from Knott's Well to West Maitland Waterworks.

Pleistocene { 1. Raised-beach.
2. Ancient flood-loam capping preceding.

Recent.........3. Recent fluviatile clay, sand, and gravel.

Permo-Carboniferous...Pp. 3. Upper Marine Series, composed of pebbly sandstones, and mud-stones.

The scales are shown on the face of the plate.

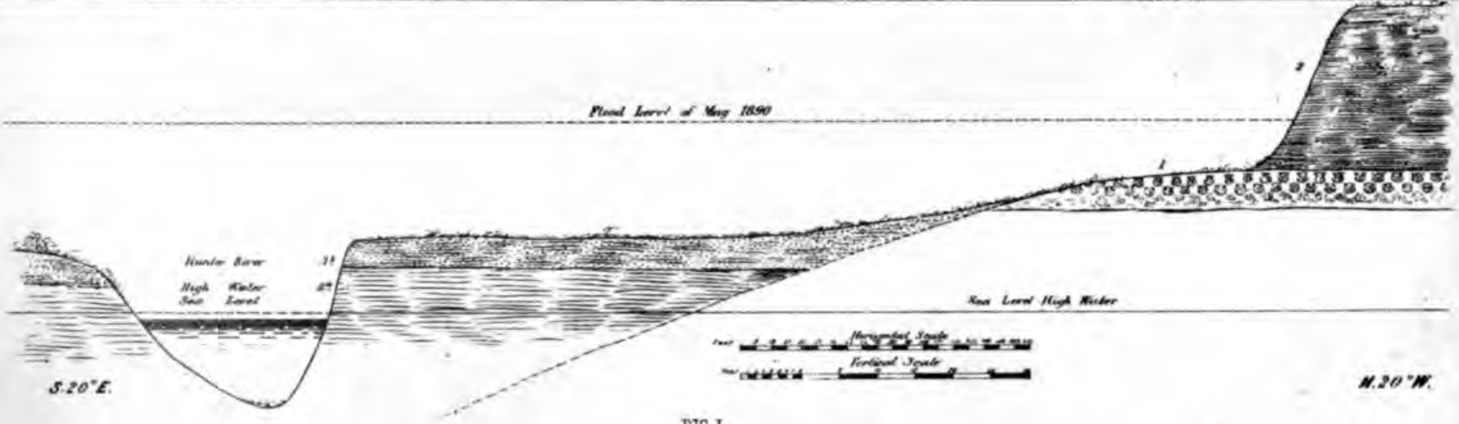

FIG. I.

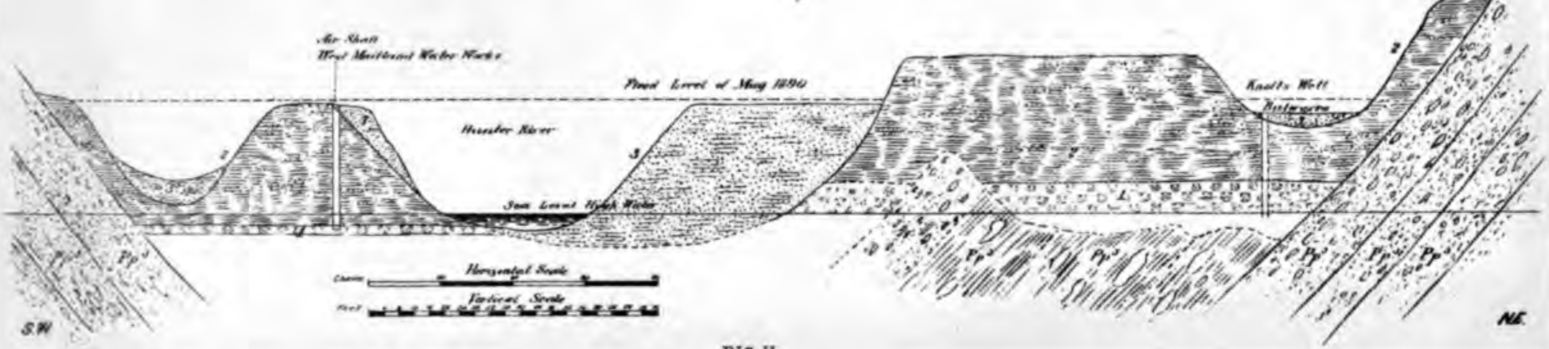

FIG II

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
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PLATE IV.

Plan of the lower part of the Panbula River, showing the positions of the Shell-heaps or " Kitchen-middens " along its banks.

a. = Partially excavated.
■ = Shell-heaps, or " Kitchen-middens."

Plate IV.

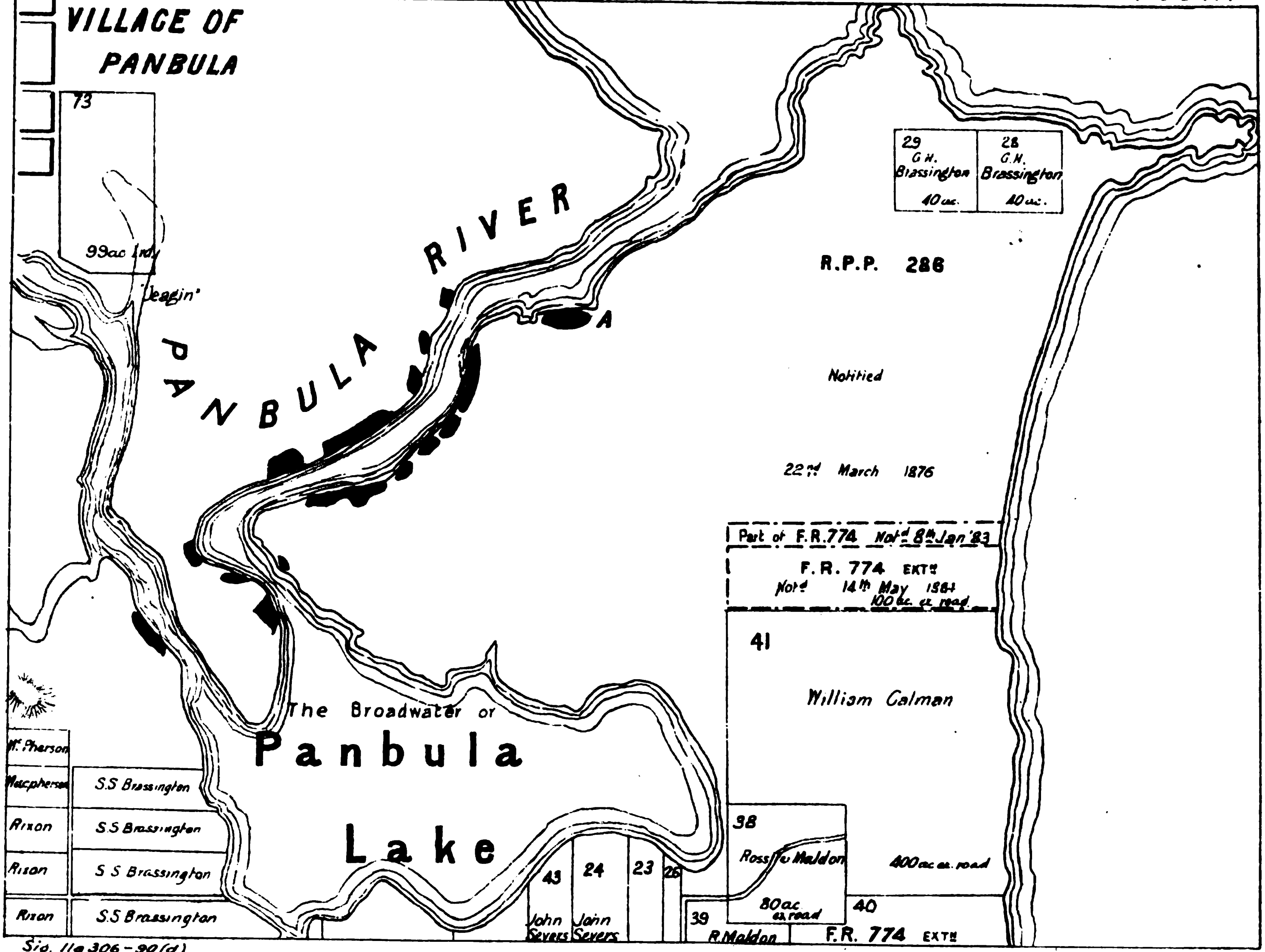

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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
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PLATE V.

Plan of the lower part of the Wagonga River, showing the positions of the Shell-heaps, or " Kitchen-middens," along its banks.

a, *b*, *c*. = Excavated.
■ = Shell-heaps, or " Kitchen-middens."

Plate V.

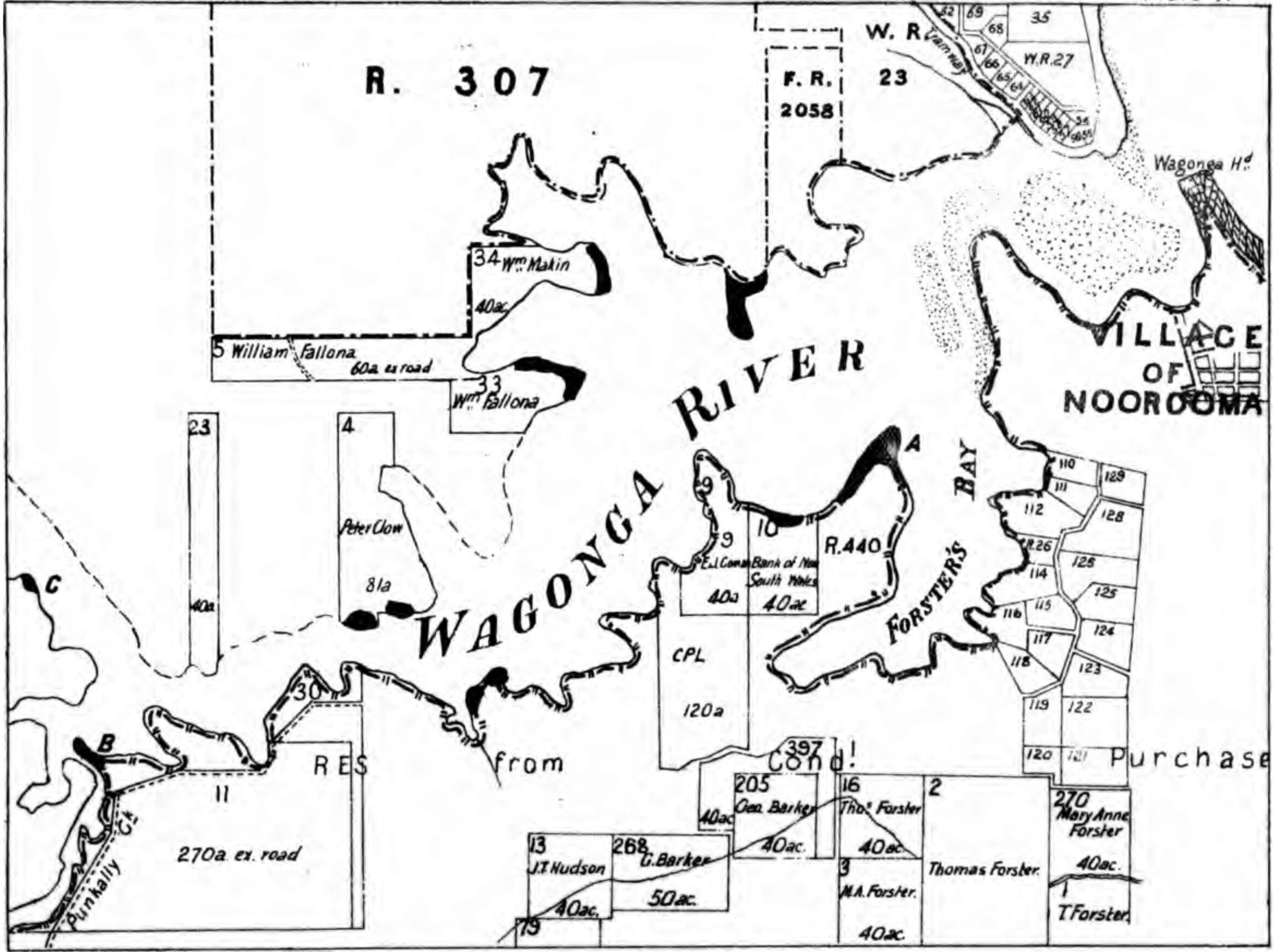

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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,

PLATE VI.

Kimberley Spear-heads.

Fig. 1. Elongately-lanceolate, angular on one face, with remains of gum-mounting at base.

Fig. 2. Elongately-lanceolate, glass, with a more decided angularity.

Fig. 3. Elongately-lanceolate, becoming more petaloid at the base.

Fig. 4. Elongately-lanceolate, variegated, the facets large, and highly dentate edges.

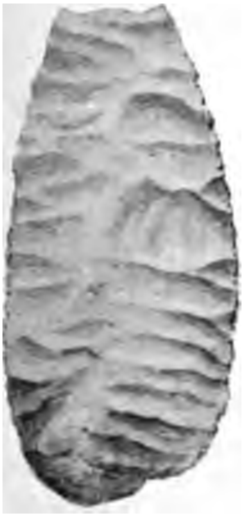
Fig. 5. Elongately-lanceolate, angled on both faces, brown chalcedonic-quartz, with strong traces of gum-mounting.

Fig. 6. Foliolate, flattened on both faces.

Fig. 7. Foliolate, flattened on both faces, the facets large, and a well-drawn out apex.

The numbers of the figures correspond to those given in the table on p. 63. The figures are of the natural size.

From drawings by Mr. G. H. Barrow, Australian Museum.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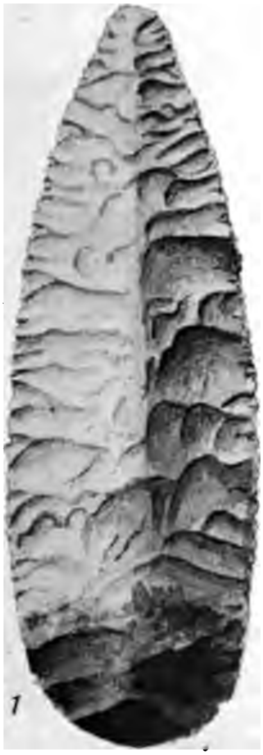
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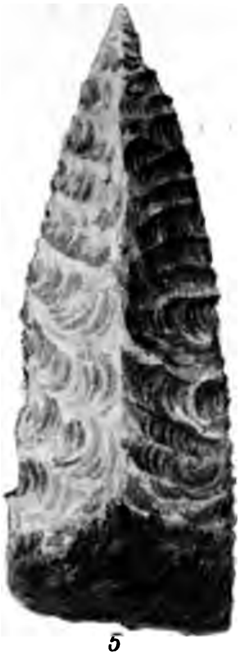
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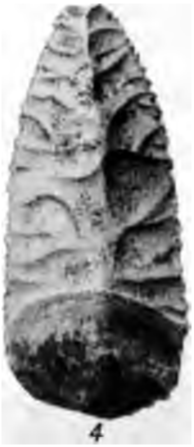
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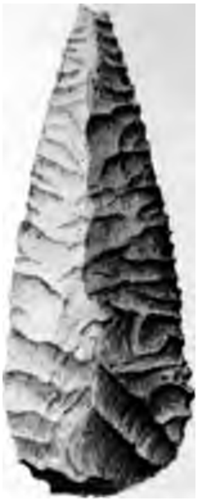
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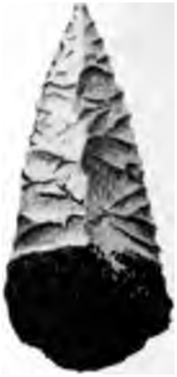
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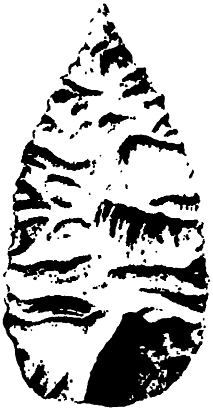
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CATALOGUE OF MINING MAPS

PUBLISHED BY THE

DEPARTMENT OF MINES, SYDNEY, NEW SOUTH WALES,

1ST JANUARY, 1889.

To be obtained at the Department of Mines, Sydney, and at the Warden's Office in the Mining District in which the land represented on the map or plan is situated.

1s. per sheet is the uniform price.

ALBERT MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Albert	Yancowinna	Thackaringa.	Mount Gipps	Yancowinna	Silverton.
Alma	do	"The Pinnacles."	Moorkaie	do	do **Mount Gipps.**
Alberta	Farnell	Corona.	Naradin	do	do
Bomangaldy	Yancowinna	Silverton.	Purnamoota	do	do
Bray	do	do	Picton	do	do **Broken Hill.**
Bolaira	do	Silverton, Round Hill.	Robe	do	do **Purnamoota.**
Bligh	Farnell	Corona.	Stephen	do	do
Badjerrigarn	do	do	Soudan	do	do
Byjerkerno	do	Poolamacca.	Sebastopol	do	do **Rockwell Paddock.**
Corona	do	Corona.	Tara	do	do **Piesse's Nob.**
Edgar	Yancowinna	Silverton.	Umberumberka	do	do
Fowler's Gap (see Giles)	Farnell		Wankeroo	do	do
Giles	do	Fowler's Gap.	Yancowinna	do	do
Lewis	Yancowinna	Silverton.			

BATHURST MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bolton (a)	Westmoreland	Wiseman's Creek.	Jocelyn	Westmoreland	Wiseman's Creek.
Baring	do		Langdale	do	do
Castleton	Roxburgh	Sunny Corner.	Lennox	Bathurst	Ophir Gold-field.
Coolamigal (b)	do	do	Lewis	do	do
Cullen Bullen	do	do	Mulgunnia	Georgiana	Mulgunnia Gold-field.
Eskdale	do	Clear Creek and Kirkconnell Gold-field.	Oberon	Westmoreland	Oberon Gold-field.
			Tuena	Georgiana	Abercrombie Gold-field.
Falnash	do	Sunny Corner.	Worcester	Bathurst	Ophir Gold-field.
Gillindich	Georgiana	Junction Point, Tuena Creek, and Markdale Gold-fields.	Do	do	do
				(Survey Office litho. adopted.)	

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nullama	Gresham	Boyd or Little River Gold-field. (Survey Office litho. adopted.)

'HUNTER AND MACLEAY MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bindera	Gloucester	Barrington Gold-field.	Craven	Gloucester	Barrington Gold-field.

LACHLAN MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bundawarrah	Bland	Temora Gold-field.	Parkes	Ashburnham	Billabong Gold-field.
Currajong	Ashburnham	Billabong Gold-field.	Young	Monteagle	Burrangong Gold-field.

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Gulgong (a)	Phillip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field.
Guntawang (b)	do	do	Wyaldra	Phillip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

Arvid	Gough	Vegetable Creek.	Land's End (o)	Gough	Emmaville Gold-field.
Annandale	Clive	do	Muir (p)	do	do
Bundar (a)	Gough	do	Marylands (q)	Buller	Wilson's Downfall.
Bookookoorara (b)	Buller	Wilson's Downfall.	Marsh (r)	do	do
Bates (c)	Clive		Paradise North (s)	Gough	Emmaville Gold-field.
Blain (d)	do		Purvis (u)	Clive	
Bowman (e)	do		Ruby (v)	Buller	Wilson's Downfall.
Binghi (f)	do		Rockvale (w)	Clive	Emmaville Gold-field.
Boorook	Buller	Boorook Gold-field.	Rockglen (x)	do	do
Boonoo Boonoo (g)	do	do	Strathbogie	do	do
Corry (h)	do	Wilson's Downfall.	Strathbogie North (y)	do	do
Cullendore (i)	do	do	Scone	do	do
Cranbrook (j)	Clive	Emmaville Gold-field.	Strachan	do	do
Callanyn	Buller	Red Rock.	Silent Grove (a^{1})	do	do
Dumaresq (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
Fraser (l)	do	Emmaville Gold-field.	Undercliff (b^{1})	Buller	Wilson's Downfall.
Flagstone	do	do	Wellington Vale	Gough	Emmaville Gold-field.
Highland Home	do	do	Wellington North (c^{1})	do	do
Hamilton (m)	do	do	Wylie (d^{1})	Buller	Wilson's Downfall.
Haystack (n)	do	Vegetable Creek.	West Fairfield	Drake	

PEEL AND URALLA MINING DISTRICT.

Aston	Hardinge	Cope's Creek.	Hall	Darling	Giant's Den.
Bangheet (a)	Murchison	Bingera Diamond-field.	Hall (k)	Murchison	Bingera Gold-field.
Bingera (b)	do	do	Mayo	Hardinge	Cope's Creek.
Boyd (c)	Gough		Mitchell (l)	Gough	
Bloxsome (d)	do		Macintyre (m)	Murchison	Bingera Gold-field.
Bald Nob (e)	do		Metz	Sandon	Hillgrove.
Clive	do	Cope's Creek.	Nundle	Parry	Peel River Gold-field.
Clare	Hardinge	do	Swinton	Hardinge	Cope's Creek
Cope's Creek	do	do	Severn (n)	Gough	
Coventry	Clarke		Scott (o)	do	
Cooney	Sandon	Hillgrove.	Sara (p)	Gresham	Mitchell River.
Darby	Hardinge	Cope's Creek.	Scone and Strathbogie	(See New England Mining District.)	
Dungowan (f)	Parry	Peel River Gold-field.			
Dinoga (g)	Murchison	Bingera Gold-field.			
Derra Derra (h)	do	do Diamond-field.	Tienga	Hardinge	Cope's Creek.
Gouron (i)	do	do do	Worra (q)	Gresham	Mitchell River.
Herbert	Gough	Cope's Creek.	Wood's Reef	Darling	Ironbark Gold-field.
Hanning	Inglis		Wellington Vale	(See New England Mining District.)	
Hall (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nerrimunga	Argyle	Nerrimunga Gold-field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Carroll (a)	Wellington	Hill End and Tambaroora.	Cummings (b)	Wellington	Hill End and Tambaroora.
Tambaroora	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

Adelong (a)	Wynyard	Adelong Gold-field.	Ellerslie (e)	Wynyard	Adelong Gold-field.
Bullongong (b)	Murray	Captain's Flat.	Euadera (f)	do	do
Ballallaba (c)	do	do	Gadara (g)	do	do
Calafat (d)	Wynyard	Adelong Gold-field.	Wodalga (h)	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. II, PART III.

1891.

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Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
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Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.
Mineral Products of New South Wales, 1882, containing:—

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3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

Mineral Products of New South Wales, 2nd Edition, 1886, containing:—

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Memoirs of the Geological Survey of New South Wales.

Geology.

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.

Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales, and Australian Museum, Sydney. (4to. Sydney, 1888.)
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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

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XIII.—Notes on a Collection of Rocks and Minerals from Mount Morgan, near Rockhampton, Queensland, collected by Mr. C. S. Wilkinson, F.G.S., &c.: by T. W. Edgeworth David, B.A., and William Anderson, Geological Surveyors. With an Introduction by C. S. Wilkinson, F.G.S., F.L.S., &c., Geological Surveyor-in-charge.

I.—Introduction.

During my inspection of the Mount Morgan Gold Mine, I collected samples of the rocks associated with the gold-bearing ore, with the view of determining the source of the gold. I entrusted the microscopical examination of these rocks to my able Colleagues, Messrs. T. W. Edgeworth David, B.A., F.G.S., and W. Anderson, Geological Surveyors, and the results of their investigation are recorded in the following paper.

The conclusions arrived at afford important information regarding the nature of the auriferous formations of which Mount Morgan is composed, and while they throw some light upon the probable origin and extent of the payable ore deposits, it is evident that further investigation is required for the elucidation of the subject.

The suggestion of Mr. R. L. Jack, F.G.S., Government Geologist of Queensland, that the auriferous deposit is of geyser origin, is supported in regard to the deposition of the gold and its siliceous and ferruginous matrix from thermal aqueous solution; but it appears that the deposit accumulated in fissures and cavities in the rocks, rather than as an overflow from the usual funnel-shaped geyser-crater.

Mount Morgan consists of highly metamorphosed sedimentary rocks, chiefly "greywacke," as Mr. Jack has termed them, which, from the fossils found in the neighbourhood, the Palæontologist, Mr. R. Etheridge, Junr., considers to be of Permo-Carboniferous age. These rocks contain auriferous iron pyrites, disseminated more or less through them—in one instance a mass of pyrites with a little silica was met with over one hundred feet in diameter—and have been intruded by dykes of hornblendic granite and porphyritic dolerite. The intrusion of the granite was probably the older, and induced the formation of the pyrites, and the siliceous induration of the argillaceous strata. Subsequently, as water passed through the jointed pyritous strata near the intrusive dolerite dykes, chemical action set in, kaolinising the dolerite and oxidising the pyrites, the gold in the latter being dissolved, possibly as sulphide, and re-deposited by itself, or with iron oxide, as the solution passed through the fissures and cavities in the rocks. Apart from the kaolinisation of the dolerite, the cavernous quartzite deprived of the pyrites which its cavities once contained, and the deposition of siliceous sinter and of hydrous iron oxide with gold, there is also evidence of chemical reaction in the aluminous rocks being highly charged with sulphate of alumina, and in the large and small yellow segregated masses of basic sulphate of iron. The latter has yielded on analysis by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department, as much as 24·419 per cent. of sulphuric anhydride, and might possibly be hereafter utilised in the manufacture of sulphuric acid.

Until further observations have been made no definite conclusion can be formed as to the source of the gold; but in my opinion the evidence so far tends to show that the gold has been derived in the manner above stated, and that the heat generated by the kaolinization of the dolerite may have largely contributed to the effects produced. If so, the payable gold-bearing ore will be found as hitherto, chiefly within the region which has been affected by the decomposition of the dolerite. The intrusion of the dolerite dykes was probably the cause of the fracturing of the strata, and it appeared to me that the principal line of disturbance is the fissure filled in with ferruginous lode stuff which was cut through in the Freehold Tunnel; the other fissures in the Mount may be connected with this, such as the small ones containing the rich gossan which has been worked at the summit. The water which first set up the chemical changes in the pyritous strata and dolerite may have permeated the fissured strata by infiltration from the surface; or it may have come up as thermal water containing gold, &c., in solution, as Mr. Jack has suggested, through a fissure or pipe from below. Even should the latter have been the chief source of the gold, yet the gold derived from the decomposition of the pyrites must have considerably enriched the deposit. I am of opinion that the payable ore is confined to the region which has been thus affected or oxidized, and that the extent of the ore can be proved by sinking in or near the Freehold Tunnel lode, close to the kaolin dyke, and driving on either side until the undecomposed pyritous rocks be met with. The principal gold-bearing deposits will, I think, be found in the vicinity of the kaolin dyke descending not vertically, but diagonally along the line of dyke in a south-easterly direction. From the examination of the rocks microscopically, Messrs. David and Anderson believe that the intrusions of dolerite are of two ages.

It is highly important that as the mine works extend, the different varieties of rock met with should be collected, and their petrological characters determined; for such investigations will prove of considerable value in connection with the discoveries of similar deposits in other localities.

The occurrence of gold that has evidently been deposited from an aqueous solution is not uncommon elsewhere; but the remarkable association of the different rocks in Mount Morgan has not as yet been observed in New South Wales.

The Mount Morgan Mine, therefore, both as regards the great extent and mode of occurrence of its rich auriferous deposits, may be recorded as unique in the history of gold mining. The natural purity, or high quality of the gold, also has been stated by Dr. A. Leibius, M.A., F.G.S., Assayer to the Royal Mint, Sydney, to be unequalled by that of any other gold hitherto found.

II.—Notes.

The rocks and minerals may be ranged in four groups:—

1. SEDIMENTARY, WITH INTERBEDDED VOLCANIC ROCKS.
    - (*a*) Quartzose argillite, an altered mudstone called "greywacke" in Mr. R. L. Jack's Report. This rock passes, in places, as near the Freehold Tunnel, Mount Morgan, into a red jasperoid claystone. Slides Nos. 26 and 27.
    - (*b*) Highly-silicated quartz-felsite, interbedded with the preceding rock. Slide No. 48.
    - (*c*) Secondary rocks, aluminous, quartzose, or ferruginous, formed from the decomposition of these Palæozoic sedimentary rocks. These secondary rocks constitute part of what Mr. R. L. Jack terms the "overflow deposit." There is no certain evidence, however, among the specimens in this collection, of the occurrence of a distinct rock species forming the so-called "overflow deposit," whose formation seems to have been largely the result of the decomposition, and subsequent molecular replacement of the minerals of the various rocks *in situ*, as is the case with those parts of the "overflow deposit" which are on the lines of the dolerite dykes. Slides Nos. 28 and 29.
2. HORNBLENDIC GRANITE, occurring in dykes about five chains north-west of Callan's Knob. Slides, 30, 31, 32, 33.

3. (*a*) ANDESITIC DOLERITES, occurring principally in dykes, which intersect the "greywacke."

    (i) Dolerite, rich in augite, *e.g.*, Slide 34, from near Telegraph Office, Mount Morgan, and Slides 35 and 36, from Freehold Tunnel, Mount Morgan.

    (ii) Dolerite, porphyritic by triclinic felspar. Slides 37, 38, 39, 40, 41, and 46.

    (*b*) Secondary rocks formed from the decomposition *in situ* of the dolerites, as the Kaolinite dykes at the summit of Mount Morgan, and certain portions of the "overflow deposit," on the line of the dykes, which are undoubtedly portions of the latter decomposed *in situ.* Slides Nos. 42, 45, and 47 (*a*, *b*, *c*).

4. SECONDARY ROCKS, including veinstones, formed of material transported by thermal waters, and derived chiefly from the rocks of 1 (*c*) and 3 (*b*). To this formation belong the spongy quartz and such aluminous and ferruginous portions of the "overflow deposit" as show evidence of having been transported. The auriferous spongy ferruginous quartz, and enclosed lumps of tubulated kaolin of Mount Morgan proper, as well as the undecomposed pyritous veinstones, probably also belong to this formation. Slides Nos. 43 and 44.

III.—Detailed description of the above-mentioned rocks.

1. SEDIMENTARY WITH INTERBEDDED VOLCANIC ROCKS.

    (*a*) Quartzose argillite from right bank of River Dee, about eight chains below the junction of Mundic Creek.

    This is a hard dark grey to greenish black, fine grained rock, irregularly jointed.

Slide No. 26, is from the Machine Site Dam, and consists of a felspathic base containing viridite and a little bluish-green chlorite with a sprinkling of macroscopic fragments of angular quartz.

Slide No. 41 may perhaps in part be from this rock altered at its contact with the dolerite dyke, which runs through the northern end of Portion 3.

Slide No. 27 is from the creek in Portion 4. It is a greenish-coloured, compact, fragmental rock resembling somewhat a volcanic tuff, consisting of a brownish-grey base of felspathic material and epidote, and containing microporphyritic abraded, or corroded fragments of quartz and felspar crystals with numerous opaque aggregations of magnetic iron. This rock is similar to No. 26.

(*b*) Highly silicated quartz-felsite interbedded with the "greywackes".

Slide No. 48 is from Mount Morgan Town, near the granitic and doleritic dykes. This is a light-grey coloured siliceous looking rock, full of macroscopic quartz crystals. Microscopically, it is made up largely of secondary quartz grains; but among these grains there is still a network of the original felsitic base. There are a few porphyritic felspars present, but the chief prophyritic ingredient is quartz, which although somewhat corroded still show crystalline edges and angles and contain included portions of the base.

(*c*) Secondary Rocks resulting from the decomposition of the Palæozoic sedimentary rocks.

Slide No. 28 is from tunnel on east side of Mount Morgan, about 250 feet from the top. This is a greenish-grey rock known as the "Mottled Rock." It consists of a translucent base of felsitic material with masses of secondary quartz and circular aggregations of microscopic crystals of iron pyrites, together with some macroscopic iron pyrites. This rock is a trifle more siliceous than No. 29 to judge from its hardness. It has probably been formed from the alteration either of the dolerite or of the fragmental Palæozoic rocks, but more probably the latter.

Slide No. 29 is also "Mottled Rock" from Mount Morgan. It is similar to No. 28 with the exception that it is more felspathic and consequently not so hard. It is also probably an alteration of the Palæozoic fragmental rocks.

2. HORNBLENDIC GRANITE. (Nos. 30, 31, 32, 33.)

Slide No. 30 was taken from a dyke near Callan's Knob. It is a crystalline-granular granite consisting of triclinic felspar, some orthoclase and mica, hornblende and quartz.

Slide No. 31 cut from a specimen collected from the front of the Telegraph Office, Mount Morgan, is a granite composed chiefly of quartz and felspar with a little hornblende and opacite. The felspar and hornblende are much decomposed. Possibly this may belong to the same eruptive mass as that from which Slide No. 30 was taken.

Slide No. 32 from top of a hill, base of Desert Sandstone, from a shaft on the side of Mount Ballad, is a granular crystalline rock composed of triclinic felspar, hornblende (primary), a little chlorite resulting from the decomposition of hornblende, opacite, and a little quartz. This is a quartz diorite resembling No. 30, with the exception that it contains far less quartz and no mica. It probably, however, belongs to the same intrusive rock-mass as Nos. 30 and 31.

Slide No. 33 is from the shaft of the Dee Prospecting Company, Mount Morgan, at a depth of three hundred and seventy feet. This is a somewhat fine-grained greenish rock, very full of iron pyrites. It is considerably decomposed, and consists chiefly of quartz and orthoclase felspar with hornblende and a green decomposition product of hornblende. Iron pyrites is very abundant in the rock, probably as a secondary constituent. This rock is similar to Nos. 30, 31, 32, but contains more quartz than No. 32.

3*a*.—ANDESITIC DOLERITES.

(i) *Dolerites rich in augite.*

Slide No. 34 is from near the Telegraph Office, Mount Morgan. It is a light grey-coloured crystalline rock, containing macroscopic iron pyrites. Microscopically it is seen to be a crystalline granular dolerite without olivine, composed of triclinic felspar, augite, and magnetite, with a little chlorite and epidote. It shows little decomposition, and the augites, which are porphyritic, are very fresh and abundant.

Slide No. 35 is from the Freehold Tunnel, east of the lode. This is a compact fine-grained, grey-coloured rock. It is micro-crystalline in structure, and is composed of lath-shaped triclinic felspar, augite, and irregular patches of a black opaque mineral, probably magnetite, some smaller crystals, which are magnetite, and a large proportion of epidote. This rock is a diabasic dolerite, and from the abundance of augite present may be classed with No. 34.

Slide No. 36 is from the south-west spur of the Sugar Loaf, Mount Morgan, and is a grey-coloured crystalline granular rock composed chiefly of triclinic felspar, augite, magnetite, and a green decomposition product (serpentine), and a little free quartz, probably secondary. This rock may possibly belong to the same eruptive mass as No. 32.

(ii) *Dolerites porphyritic by triclinic felspar.*

Slide No. 37 is from tunnel in Portion 3. It is a light grey coloured rock, spotted over with the fractured faces of the large porphyritic felspars. The rock, which Mr. R. L. Jack classed provisionally as a rhyolite, basing his determination on such evidence as was available for him in the field, proves upon subsequent microscopic examination to be a diabasic dolerite, porphyritic by triclinic felspar, with an occasional porphyritic crystal of augite. It consists of a base of triclinic felspar, magnetite, and augite, with porphyritic crystals of triclinic felspar, showing well marked zonal structure, a little undecomposed pyroxene, and a large proportion of greenish decomposition products.

Slide No. 38 is from Portion 95, Sunbeam Tunnel, Mount Morgan. This is a diabasic dolerite resembling No. 37. It consists of a micro-crystalline base of lath-shaped felspars, augite and magnetite with greenish decomposition products, and porphyritic crystals of triclinic felspar and micro-porphyritic crystals of augite. The base of this rock is very finely crystalline, and shows basaltic structure.

Slide No. 39 is from Portion 95, Sunbeam Tunnel, Mount Morgan, and is evidently the same rock as No. 38, a diabasic dolerite. It is a little more decomposed, and more coarsely crystalline in the base than No. 38.

Slide No. 40 is from the Mundic Reef Shaft, Mount Morgan. This is a light grey finely crystalline rock, consisting of triclinic felspar, augite, greenish decomposition products and a little magnetite, with porphyritic crystals of triclinic felspar. This is certainly an igneous rock and belongs to the diabasic dolerites.

Slide No. 41 is from tunnel on Portion 3, Mount Morgan, and is a fine-grained compact dark-coloured rock containing iron pyrites. It is much decomposed and may be classed as a diabasic anamesite. It consists of a micro-crystalline mass of lath-shaped triclinic felspars with abundant magnetite, various greenish minerals, some of which are chlorite, resulting from the decomposition probably of augite, and a little decomposing augite with a sprinkling of angular primary quartz, perhaps derived from the "greywacke."

Slide No. 46 is from a depth of five hundred and sixty feet in the diamond drill bore at Mount Morgan. The rock is a diabasic anamesite, and may be classed with No. 41. It contains a good deal of free quartz, but consists chiefly of a base formed of triclinic felspars and much decomposed augites, with magnetite and iron pyrites. The porphyritic minerals are triclinic felspars, some of which are quite fresh, the majority, however, being much clouded, and a light-green mineral which is undoubtedly decomposed augite, some portions of the crystals still being fresh, brown-coloured, and pleochroic. In some cases the larger quartzes seem, from the abundance of inclusions, to be primary in their origin, while most of the interstitial quartz in the base is certainly of secondary origin due to infiltration.

3*b*.—SECONDARY ROCKS FORMED FROM THE DECOMPOSITION OF THE DOLERITES.

Slide No. 42 is from (A), on Jack's plan of Mount Morgan. Macroscopically, this rock can be distinctly seen to be a decomposed and kaolinised form of the diabasic dolerites which are porphyritic by felspar. It consists of a micro-crystalline base of kaolinised felspar, ferrite, and limonite with porphyritic crystals of kaolinised triclinic felspar. Most of the kaolinised porphyritic felspar crystals are surrounded by cracks which radiate from them into the base, where they die out. These cracks may probably be due to the expansion of the individual crystal of felspar during its kaolinisation. This rock is no doubt a decomposed form of Nos. 37, 38, or 39.

Slide No. 45 is from the south-west spur of the Sugar Loaf, on road near Dee River, Mount Morgan. This is a white kaolin rock. The section shows well-defined somewhat angular areas, scattered through it. These have all the appearance of kaolinised felspar crystals, and they no doubt represent the porphyritic felspar crystals of the unaltered rock, which in this case was unmistakably a diabasic dolerite similar to Nos. 37, 38, and 39, if not identical with the latter two.

Slides No. 47, *a*, *b*, *c*, are from the west side of Mount Morgan. They are light-brown finely-speckled rocks, chiefly composed of kaolin with fine siliceous veins traversing them, and small irregular areas of decomposition filled with secondary quartz, there is a considerable quantity of a black opaque iron compound present. Although the evidences of the presence of the decomposed porphyritic felspars are not so apparent as in the case of Nos. 42 and 45, still there is little doubt but that this kaolinite has resulted from the decomposition and alteration of one of the andesitic dolerites.

4. SECONDARY ROCKS.—Including vein-stones, formed of material transported by thermal water, and derived chiefly from the rocks of 1 (c) and 3 (b).

Slide No. 43 is from Portion 95, Sunbeam Tunnel, Mount Morgan, and is a greenish-coloured compact siliceous-looking rock containing a great deal of macroscopic pyrites. Microsopically it consists principally of mosaics of secondary quartz with fragments of primary quartz, abundant crystalline aggregates of secondary pyrites and serpentinous material. This rock has probably resulted from the alteration of serpentine or, possibly, from the diabasic dolerites into a siliceous rock, the silica having largely replaced the original constituents.

Slide No. 44 is from the east side of the lode in the Freehold Tunnel, Mount Morgan. This rock is a pyritous serpentine consisting of a serpentinous translucent base, through which are distributed macroscopic and microscopic crystals of iron pyrites in great abundance, and great numbers of microscopic crystals, which, judging from their geniculate twinning, are very probably rutile. Macroscopic enclosures of a rock which may probably be either fragmental or doleritic occur at intervals. This rock is so largely impregnated with secondary pyrites as to leave its original nature a mere matter of conjecture.

IV.—Conclusions.

The conclusions that seem to follow from the microscopical study of this collection of rock specimens from Mount Morgan may be summed up thus:—

That all the rocks in the immediate neighbourhood of Mount Morgan proper, and the other isolated centres from which hot siliceous waters or vapours emanated, have been very much altered.

That the Palaeozoic rocks of the district have been intruded by irregular masses of granite and dykes of dolerite.

That the dolerite dykes are probably of two ages. Some of them are allied to the granites and are probably of the same age, while others of them were probably a distinct eruption.

That the activity of the geysers which produced the alterations in the rocks was subsequent to the intrusion of these eruptive rocks.

That the so-called overflow deposit is not really a surface deposit, but has been largely formed of the various rocks altered *in situ.*

That this alteration has been brought about in the vicinity of the pipes of the geysers, at all depths from the original surface downwards, where considerable areas of the rocks through which the pipes passed have undergone a process of digestion in the hot silicified waters or vapours which soaked away from these pipes as a centre. On the cessation of the activity of the geysers, the place of the minerals which had been decomposed out of the various rocks, would be occupied by the deposition of silica from the cooling waters.

That wherever the dolerite dykes are present in this area, which has been saturated with the siliceous waters, they have been more or less altered into kaolinite.

XIV.—Laboratory Notes on some New South Wales Minerals: by J. C. H. Mingaye, F.C.S., Analyst and Assayer.

Note I.—A Mineral resembling Tasmanite.

A greyish coloured shale, somewhat resembling Tasmanite in appearance, from Gunnedah, on being submitted to a proximate analysis, yielded as follows:—

Hygroscopic moisture	1·35
Volatile hydrocarbons	32·18
Fixed carbon	3·61
Ash	62·86
	100·00

Specific gravity—1·755.

Sulphur in shale—1·208 per cent.

No true coke formed, a dark powder being left. Ash—reddish tinge, dense.

Under the microscope a section of the shale had the appearance of consisting of a number of seed-like spores, and large pieces of stone, containing pyrites, were also visible. On heating, the mineral evolved sulphurous acid, and on ignition gave off a smoky fetid smell. It was acted upon to some extent by alcohol, ether, and carbon-bisulphide, the extract having a yellowish resinous appearance. On distillation it yielded a heavy oil and solid product, having a very disagreeable odour.

This mineral, though somewhat resembling Tasmanite, is shown by its insolubility in alcohol, ether, and carbon bisulphide not to differ from the resiniferous shale described* by Professor Church, who states that it is not dissolved in the least degree by alcohol, ether, &c.

It is evidently worthy of a more detailed examination, and an ultimate analysis would be of value, which I am sorry to say could not be performed, as the amount of it at my disposal was small. I hope shortly to obtain sufficient to make an analysis, and also an examination of the oils and solid products.

Note II.—On the occurrence of Platinum "in situ" in N. S. Wales.

A sample of tailings and slimes obtained from a mine in the Orange District, by Smith and Party, was submitted for assay by the ordinary method, *i.e.*, fusion and cupellation, when it was noticed that the gold buttons contained some foreign metal. An examination being made detected the presence of small quantities of Platinum. The slimes yielded 2 dwt. per ton, the tailings much less. Platinum was also found in some ferruginous felspathic rock with magnetite, obtained from Surface Hill, Wollombi; the sample of stone sent, however, being small, an estimation could not be made until a larger sample was supplied.

The occurence of Platinum "in situ" in a felspathic lode material in the Broken Hill District has been previously pointed out by me in the Annual Report of the Department of Mines, 1889, p. 240, and in a paper read before the Royal Society of N. S. Wales, November 6th, 1889.

Note III.—Analysis of a Water taken from a Hot Spring, Yarrangobilly Caves.

Total solid matter, 9·044 grains per gallon.

Analysis.	Grains per gallon.
Carbonate of lime	6·552
Carbonate of magnesia	nil
Silica	·868
Alumina	trace
Chloride of sodium	1·318
Strong trace of strontia, nitrates, and undetermined...	·306
	9·044
Free ammonia	nil.
Organic or albummoid do	·026 per million parts.
Chlorine	·8 grains per gallon.

Water free from odour, clear. An excellent description of spring water.

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* Phil. Mag, 1864, xxviii, p. 465.

XV.—On the Occurrence of Microscopic Fungi, allied to the Genus *Palæachlya*, Duncan, in the Permo-Carboniferous Rocks of N. S. Wales and Queensland: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate VII.]

IN 1876 Prof. P. M. Duncan, F.R.S., described certain microscopic bodies penetrating the shells of Silurian and Devonian Brachiopoda, and the tissue of Tertiary Corals.* To these the author applied the name of *Palæachlya perforans*, regarding the organism as an endophytic unicellular alga, allied to the living *Achlya*.

Previous to Duncan's researches, similar bodies, he tells us, had been studied by the late Prof. Quekett, the late Dr. W. B. Carpenter, A. W. Kollicker, and C. Wedl, and references were made to their writings. Quekett and Wedl considered the endophytes to be confervoid algæ, Kollicker as parasitic fungi, and Wedl even going so far as to refer them to the existing *Saprolegnia ferax*, Kützning. Then, says Dr. Duncan, "these investigations showed that there were parasitic vegetable growths in modern corals, and in many shells, even as old as the Devonian, and that they were either confervæ or fungi."

Whilst studying the microscopic structure of Monticuliporoid corals from the Permo-Carboniferous of N. S. Wales and Queensland, my attention was attracted to some spicular-looking hollow tubes on the one hand, within the corallites of *Stenopora crinita*; and meandering perforating tubes in the corallum of another Monticuliporoid on the other—in both cases clearly no part of the respective organisms themselves.

Before proceeding to describe the Australian forms, it is necessary for the proper understanding of their structure, to give an epitome of that of *Palæachlya perforans*, as described by Duncan.

In the Tertiary corals examined by the latter, the canals branch and end in *culs de sac*, possess dark borders, and a refractive central area. In the Silurian coral *Goniophyllum pyramidale* the tubes or canals have no proper wall, but are simply excavated out of the coral substance. They occur either just beneath the surface, parallel to it, or pass inwards at different angles, with an average diameter of 0·008 inches, and are usually straight, although sometimes branching, the calibre differing but little either in a parent tube or its branches. Both are usually filled with a dark granular matter, except in the middle line, thus giving rise to dark edges and a clear centre. As a rule the tubes have no definite origin or ending, but at times they terminate in *culs de sac*, as in the case mentioned above. In other instances, the tubes arise from dark spots, larger than their diameter, filled with a mass of globules; or, dark globular pigment masses are in contact with one end, and are either much crowded* or arranged in disconnected linear series†. The globules are probably the remains of resting spores, and the pigment masses of conidia. In the section of *Calceola* some of the larger tubes end at the surface in a loculus‡ crowded with spores, having a black globular appearance.

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* On some Unicellular Algæ parasitic within Silurian and Tertiary Corals, with a Notice of their Presence in *Calceola* and other Fossils.—*Quart. Journ. Geol. Soc.*, 1876, XXXII, p. 205.

Such is the general appearance presented by the bodies described by Professor Duncan. The Australian forms will now be described, then their analogy pointed out, and finally their relations to living forms discussed. It will be most convenient to describe the Queensland fossil first, as its structure approaches nearest to that of *Palæachlya perforans.*

The entire corallum of the Monticuliporoid, so far as preserved, is thickly permeated with very minute tubes in all directions (Pl. VII, Fig. 1), parallel to the direction of growth of the corallites, transverse to the same, or at an oblique angle. These tubes are flexuous in habit, circular in section (Pl. VII, Fig. 1), and with their terminations, when seen, irregularly enlarged, and there are occasional enlargements in the course of a tube. There also appears at times to be a dichotomization, a tube subdividing into two branches. The different directions in which the tubes permeate the corallum renders it impossible to figure the course of a tube for any extent of its length, but a fairly good idea may be obtained from Pl. VII, Fig. 1. There appears to be a definite wall represented by a line of darker colour on each side of a tube's course, the centre being either refractive, or filled with granular matter, finely divided, of a uniform dark sherry-yellow. In only one instance have I seen any trace of spores, and these partake of the same character as those presently to be described in the form from New South Wales, round globular black bodies. It is proposed to call this perforating form of the Queensland Permo-Carboniferous *Palæachlya tortuosa*, in allusion to the very irregular and winding course of the tubes. With the exception of Duncan's figures, I have only met with one illustration of a similar organism, that given by Messrs. Wagen & Wentzel, who figure§ it permeating the tissue of *Geinitzella columnaris*, Schlotheim, sp., from the Cephalopoda bed of the Upper Productus Limestone of Chedru, Salt Range, India. It is exceedingly like the Australian form, but whether identical or not, it is difficult to say.

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* Duncan, *Loc. cit.*, t. 16, f. 3, 5.
† Duncan, *Loc. cit.*, t. 16, f. 8.
‡ Duncan, *Loc. cit.*, t 16, f. 12 and 13.
§ Pal. Indica, Ser. xiii., Salt Range Fossils, 1886, I, Pt. 6, t. 115, f. 1.

The bodies discovered in the calices of *Stenopora crinita*, Lonsd., differ much from those just described, both in form and habit. They are straight, tubular organisms, tapering to an acute and apparently closed distal end, whilst the proximal is inflated into a globular chamber, the whole organism having much the appearance of a pin, (Pl. VII., Fig. 2), or, to speak more precisely, the spicules of the sponge, *Axinella*, Hinde.[*] It is proposed to apply to these the name of *Palæoperone*[†] *endophytica.* They occur in matted clusters and small irregularly-arranged bundles, and although more or less variably placed as regards one another, are usually sub-parallel to the direction of the corallites. In a few instances the tubes have been seen across the corallite containing them, but there is no evidence that the corallite wall is ever pierced. In this position their hollow condition becomes apparent, and also the presence of a proper wall, shown by a dark encompassing line, and they are generally filled with an amber-yellow colouring matter. In one instance, however, the proximal end of the tube is occupied by five round spore-like bodies (Pl. VII., Fig. 3) in linear series of a black colour. These are probable spores, and in that case the spicular tubes would represent sporangia, of course assuming the former to be in place. The contiguous tube to that just referred to presents a similar space to that occupied by the five spores, but devoid of such, or even the yellowish colouring matter, and its appearance suggests the former presence of spores, which had possibly swarmed (Pl. VII., Fig. 3). In a third case, the distal portion of a spicular tube is filled with a dark homogenous colouring-matter, the middle portion is clear, whilst at the proximal end occurs a cluster of spores, quite similar to some of Professor Duncan's figures of *Palæachlya perforans*,[‡] and possibly in the act of swarming. The only other departure from the infilling of amber-yellow colouring-matter, occurs in the larger portion of some of the tubes when filled with a dense black deposit. The proximal distentions of the tubes, taking the place of the pin-heads, to carry out the simile, differ from those of *Palæachlya* in that they are terminal, and not irregularly placed along the course of the tube. The two forms further disagree in the irregular course pursued by the one, and the brief and rigid length of the other, sometimes, but not often, very slightly curved.

I now come to a very interesting point in this investigation—the nature of the black masses infilling a few of the spicular tubes. A number of the corallites of *Stenopora crinita* in the immediate neighbourhood of the endophyte, are more or less filled with an identical black deposit, the partial infilling usually taking the form of a lining along the corallite walls. When in the latter condition these masses gradually become disintegrated towards their inner margins, and dissolve into a multitude of minute densely black opaque globules, of variable size, similar in appearance to the five (Pl. VII, Fig. 3) occupying the proximal end of one of the spicular tubes, or sporangia, and previously spoken of as spores. In some instances these globules are loosely aggregated in the corallites, and in either of these conditions are presumed to represent spores which have swarmed. The identity of those massed in the corallites of the *Stenopora*, with those at the proximal end of the sporangium (Pl. VII, Fig. 3), seems affirmed by their respective form, size, opacity, and general appearance. I have submitted these globular masses to a very careful examination in company with my Colleague, Mr. T. W. E. David, B.A., and we have come to the conclusion that the present condition of the globules is that of iron pyrites. If we suppose the original spores to have assumed the properties of a hydro-carbon, apparently the composition of cryptogamic spores during Palæozoic times—these coming in contact with sulphate of iron in solution, an interchange would result in the formation of carbonate of iron, and elimination of sulphuretted hydrogen. A replacement of the carbon by sulphur would produce the desired iron pyrites. One point is certain, the black globular bodies do not occur in the matrix, external to the *Stenopora* tubes, and thereby form one of its constituents.

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[*] Mon. Brit. Foss. Sponges, Pal. Soc., 1888, Pt. 2, p. 145.

[†] *ἡ περόνη*, a pin.

[‡] *Loc. cit.* t. 16, f. 12 and 13.

It is almost needless to repeat the observation that the two forms here described differ much in appearance and habit, and it is only the Queensland fossil which is definitely allied to Duncan's *Palæachlya*. For my own part, I am content to accept his views of the affinity of that fossil, and to adopt them for that here called *Palæachlya tortuosa*, without further discussion. As regards *Palæoperone endophytica*, however, the affinities are not so clear, but I would tentatively call attention to its general resemblance to the Saprolegnean group of Fungi. According to De Bary,* "The genera Saprolegnia, Achlya, and Dictyuchus, when well developed have club-shaped sporangia, the protoplasm of which divides into numerous spores arranged in many rows. Very feeble specimens form only one row of spores, and there is scarcely ever more than one row in the long narrowly cylindrical sporangia of Aphanomyces." When discharged the spores become collected at the mouth of the sporangium in little groups, from which they afterwards burst to swarm. This is excellently shown in a figure of *Achlya*, given by De Bary †; and another by Van Teighem.‡ The larger number of the Saprolegniæ live in water, on animal or vegetable matter, during decomposition, and in liquids charged with organic substances. Le Maout and Decaisne § give a series of figures of *Saprolegnia ferax* in different states of development from the fungus in the form of radiating hyaline filaments covering a dead fly, to the process of swarming of the spores. In their figures the proximal ends of the filaments, forming sporangia, contain numerous granules, or spores, shut off from the remainder of the filament by a septum.

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* Comparitive Morphology and Biology of the Fungi, Mycetozoa, and Bacteria, by A. de Bary (English Edition, by Garnsey and Balfour, 8vo. Oxford, 1887), p. 143.

† *Loc. cit.* p. 143, f. 70.

‡ Traité de Botanique, 1884, p. 1025, f. 618.

§ Traité generale de Botanique, Descriptive et Analytique, 1876, p. 716.

The supposed spicule-like sporangia (Pl. VII., Figs. 2 & 3), it is quite clear, have no connection with the coral *Stenopora*, nor are they the spicules of a sponge, notwithstanding that the simulated appearance of some forms of the latter is striking. A close resemblance exists between the pin-like sporangia of *Palæoperone endophytica*, and the globular-headed gonidiophores of *Phycomyces nitens*,[*] a terrestrial fungus of the group Mucorini; and a similar organ is developed by *Saprolegnia dioica*.[†] The single row of spores seen in Pl. VII., Fig. 3, would correspond to the "very feeble specimens" of the genera mentioned by De Bary, whilst in Pl. VII, Fig. 2, we have the spores discharged from the sporangium in a somewhat similar manner to that exemplified in De Bary and Van Teighem's figures of *Achlya*.

The views here enunciated, are so tentatively, with the view of drawing attention to this very interesting fossil, but if a more satisfactory solution of its affinities can be suggested, the Author will be prepared to accept them.

It may not be out of place to state, in conclusion, that several other instances of Palæozoic Fungi are on record. For instance, the late Messrs. Hancock and Athey in their paper, "On some curious Fossil Fungi from the Black Shale of the Northumberland Coal-field," described[‡] under the name of *Archagaricon* lenticular bodies with tubular ramifications, and therefore quite unlike even our Queensland form. On the other hand, *Peronosporites antiquarius*, Wn. Smith[§], possesses globular oogonia or sporangia supported on distinct threads. It is one of the Saprolegnieæ occurring in the British Coal Measures, and is probably closely allied to *Palæachlya*. Mr. Worthington G. Smith also describes another sporangium of a Fungus from the Coal Measures as *Protomycites protogenes*,[¶] but less is known of this than the former.

It is unnecessary to refer to the genus *Traquaria*, Carruthers,[‖] as this has been shown[**] by Prof. W. C. Williamson to be probably a cryptogamic macrospore; nor to the peculiar bodies figured by the last-named author as conceptacles [*Sporocarpon*, *Zygosporites*, *Calcisphæra* and *Oidospora*,],[††] as although they are low forms of animal or vegetable life, they are not regarded as of a fungoid nature.

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[*] De Bary, *Loc. cit.*, p. 146, f. 71.

[†] *Le Maout and Decaisne*, *Loc. cit.*, p. 716, fig.

[‡] Ann. Mag. Nat. Hist., 1869, iv., p. 226.

[§] Diseases of Field and Garden Crops, chiefly such as are caused by Fungi, 1884, p. 332, f. 139.

[¶] *Ibid*, p. 333, f. 140.

[‖] Brit. Assoc. Report for 1872 [1873], p. 126.

[**] Phil. Trans. R. Soc. for 1880 [1881], clxxi, p. 511.

[††] Phil. Trans. R. Soc. for 1878 [1879], clxix, Pt. 2, p. 357; *Ibid* for 1880 [1881], clxxi, Pt. 2, p. 507.

XVI.—The Associated Minerals and Volatility of Gold: by T. W. EDGEWORTH DAVID, B.A., Geological Surveyor.

I.—Introduction.

THROUGH the kindness of Dr. J. Storer and Dr. S. P. Mackenzie, copies have been lately supplied to me of three papers recently read before the American Institute of Mining Engineers, on subjects of such immediate importance to mining and metallurgy in this Colony, that I feel justified in inviting attention to the new trains of thought suggested by these papers.

II.—W. M. Courtis on Gold Quartz.

The first on "Gold Quartz," by W. M. Courtis,* treats of the distinguishing microscopical characteristics of respectively good and poor gold-bearing quartz. While admitting that the evidence so far collected by him is not finally conclusive, Mr. Courtis argues that as a rule good gold quartz contains far more microscopic fluid enclosures and cavities than barren quartz, and in the former such enclosures show a tolerably uniform parallellism of arrangement, whereas in the latter they are somewhat irregularly distributed.

III.—Collateral Evidence.

The fact has long been known to geologists that liquid carbonic acid gas is present in globules of microscopic size in the quartz of granite, and also in that of many veinstones, and as it is known by laboratory experiments that a pressure equal to forty atmospheres (about three hundred and fifty tons per square yard) is necessary for converting carbonic acid gas into a liquid state, this is often quoted as a proof of the great pressure under which such granites and veinstones must have been formed. It is not only, however, in the form of carbonic acid gas (carbon-dioxide) that carbon has been proved by petrologists to be present in metalliferous veins, but also as graphite and anthracite. The colouring matter of fluor spar and of smoky quartz has also been attributed to carbon in some form, though in the case of the latter mineral the smokiness of the quartz is thought by some to be due to the presence of titanic acid, such quartz usually containing numbers of needle-shaped crystals of that mineral. That carbon is present as a deep-seated mineral at certain localities, where quartz veins are even now in process of formation, is proved by its abundant discharge at some volcanic vents and solfataras. The Author of the paper above referred to on gold quartz has detected the presence of liquid carbonic acid in many of the gold-bearing quartz-veinstones of Calaveras County, California.

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* Trans. American Inst. Mining Engineers. Gold Quartz. By W M. Courtis, Detroit, Mich. (Ottawa Meeting, October, 1889).

The presence of liquid carbonic acid in some quantity in the rich parts of the gold-bearing quartz veins above mentioned is obviously of great interest taken in consideration with the well-known influence of carbon in precipitating gold in a metallic form from solution. As far back as 1866, Mr. C. S. Wilkinson, F.G.S.,* demonstrated by practical experiment that the introduction of a piece of wood into a solution of chloride of gold brought about a precipitation of the gold in a metallic form; and, later on, Mr. J. Cosmo Newbery B. Sc.† discovered that gold was actually present in minute quantities in the interior of some of the props, which had been standing for many years, partly immersed in the water draining from various gold-mines in Victoria. Some recent researches, on the other hand, by Mr. C. S. Wilkinson, upon wood, which had been standing for some time in the water draining from the Mount Morgan gold-mine, showed that even traces of gold were absent. The timber, however, tested had been standing in the mine for only about twelve months.

The property of wood, or rather of the carbon contained in it, to precipitate gold in a metallic form has been taken advantage of in the Newbery-Vautin Process for the extraction of gold by chlorination, the gold in the latter part of the process being precipitated in a metallic state from the solution of chloride, by the action on the latter of the powdered charcoal employed in the charcoal filters. Carbon, therefore, being proved to have the power of precipitating gold from chloride solutions,‡ artificially produced, it is not unreasonable to suppose that if such solutions were formed naturally in the channels of veins, previous to the consolidation of the veinstone, they would be liable to have a portion of their gold precipitated where they came in contact with carbon, which might be present in the form of graphite either formed primarily from the alteration of vegetable matter; or secondarily, from the breaking up of carbonic acid into its constituents—carbon and oxygen—the oxygen being absorbed through the conversion of sulphides into sulphates, or through the oxidation of metallic solutions. The theory has already been advanced by Mr. W. H. Rands, Assistant Government Geologist of Queensland,§ that much of the gold in the Gympie reefs has probably been precipitated by the action of the carbon of the sedimentary rocks traversed by the reefs upon the original gold solutions, from which the reefs were formed.

The association, therefore, of microscopic globules of liquid carbonic acid gas with gold in the good gold quartz in some of the Californian mines may be an essential rather than an accidental attribute, and if so a study of this branch of inquiry, if applied to the gold-bearing veinstones of New South Wales, would probably lead to some practical results as affording a possible means of determining, merely by a careful microscopic examination of surface specimens from a reef, whether that reef is likely or not to be gold-bearing at a depth, even when there is little indication of its being gold-bearing at the surface. The subject at all events has much to commend itself to the attention not only of the geologists on this Survey, but also to that of any who propose to study systematically the laws which govern the occurrence of gold in gold reefs. The observations, however, lately made by Mr. C. S. Wilkinson, at the Mount Morgan Mine, incline him to believe that in the solutions from which the gold at this mine was precipitated, gold was present as a sulphide rather than as a chloride, as might be inferred from the abundance there of basic sulphate of iron, the occurrence of which at Mount Morgan was first observed by Mr. Wilkinson. In the work which is now being prepared by the Geological Survey on the microscopic and other characters of the eruptive rocks of New South Wales, special attention will be given to the metalliferous veinstones, and the formations with which they are associated, more especially with reference to the probable form in which gold occurs (when present otherwise than as "free-milling" gold) in pyritous veinstones.

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* Trans. R. Soc. Vict., 1868, VIII, p. 11; Siluria, by R. I. Murchinson, 1872 p. 465; Gold, by Lock, p. 759.

† Gold, by Lock, 1882, p. 777.

‡ Mr. Skey, however, contends that carbon acts less effectively than metallic sulphides as a precipitating agent on solutions of gold.—*Report Austr. Assoc. Adv. Sc. for* 1888 [1889], I, p. 155.

§ Gympie Gold Field Report, by W. H. Rands. *Queensland Parl. Papers*, 1889, C. A. 7, p. 4.

IV.—Association of Gold with other Metals.

The question as to the form in which gold occurs in the pyritous portions of gold-bearing veins is obviously one of vast importance to the interests of gold-mining in New South Wales, in view of the fact that hundreds of gold veins, which proved payable as far down as their oxidised portions extended, and the gold was consequently capable of being extracted by amalgamation, have had to be abandoned as soon as the sulphide ores were reached below the lowest limit of the zone of oxidation, which is commonly found to be co-incident with the water level. Below this point the yield of gold becomes diminished from two causes:—

(1) The specific gravity of the stone is frequently materially increased, so that the yield of gold per given weight of stone is lessened. For instance, if in the oxidised portion of the vein the stone weighs (say) two and a half tons per cubic yard, and yields one ounce of gold per ton, a cubic yard of the same veinstone, where highly charged with sulphide ore below the water level, if it weighs five tons instead of two-and-half, would yield only at the rate of one-half ounce of gold per ton. Such great differences, however, in the relative specific gravities of the oxidised, as compared with the unoxidised portions of veinstones, are rather exceptional, and the falling off of the yield of gold is therefore attributable, probably, rather to the second cause about to be described.

(2) The gold for the greater part in most sulphide ores ceases to be "free milling," and cannot, therefore, be extracted, excepting to a limited extent, by the ordinary processes of amalgamation. This resistance of gold, when in sulphide ores, to the amalgamating influence of the

> mercury, has been attributed chiefly to two possible causes—(*a*) to the gold in the sulphides and arsenides being in an excessively fine mechanical state of division, so that the gold, though free (on this assumption), floats away in the water after it leaves the stamp-boxes without being attacked by the mercury; and (*b*) to the gold in the sulphides being present in some form other than as free gold, that is, chemically combined or alloyed with some other element.

This subject has been admirably treated in a paper on "The Association of Gold with other Metals in the West," by Richard Pearce.*

(*a*) MR. PEARCE'S EXPERIMENTS.—Mr. Pearce quotes some interesting experiments conducted by himself, which seem to show that in the case of the gold veins of Gilpin County, Colorado, the gold in the sulphide-bearing portions of the vein is combined in many cases with minute quantities of bismuth, in some cases with tellurium, and possibly in a few cases with arsenic. The discovery of sperrylite (arsenide of platinum) in Canada suggests to him the possibility of the occurrence of gold similarly combined, and he is of opinion that it is possible to produce arsenide of gold in minute quantities artificially, by passing the vapour of arsenic over thin sheet gold at red heat in an atmosphere of hydrogen, the surface of the gold during this experiment becoming covered with "a very fine greyish coating, * * which may have consisted of a compound of gold with arsenic." He does not, however, speak positively upon this point. The facts however, which he seems to have established with regard to the gold veins of Gilpin County, below the water level, are—

(1) That the gold is paler and baser here than in the upper oxidised portions of the veins.

(2) That tellurium and bismuth are frequently present, and sometimes arsenic, though little or no arsenical pyrites is observable.

And by practical experiment he has demonstrated that—

(1) Compounds of gold and bismuth, and of gold and tellurium, can be artifically formed, and that such artificial compounds are not attacked by mercury.

(2) Compounds cannot be formed of pure gold and iron pyrites by melting them up together, the gold remaining simply in a mechanical state of division in the pyrites, and not losing its standard.

(3) If bismuth be added to the gold and iron pyrites, and the three fused together, the matte so formed shows no trace of metallic gold, the gold having probably combined with the bismuth.

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* The Association of Gold with other Metals in the West, by Richard Pearce, Argo, Colorado. *Trans. American Inst. Mining Engineers.* (Presidential address at the Washington Meeting, February, 1890.)

(4) If silver be added to the gold, iron pyrites, and bismuth, the gold does not combine with the bismuth, but forms a silver-gold alloy with the silver.

(5) If copper be added to the iron pyrites, bismuth, gold, and silver, the gold forms an alloy with the copper, but not with the bismuth and silver.

The last experiment, however, was tried only in the case of copper matte formed during the ordinary process of smelting, in which there was only a comparatively small percentage of silver and bismuth present.

Upon treating the matte with nitric acid Mr. Pearce observed that when the rest of the metals in the matte had passed into solution "very minute octahedra of this gold and copper alloy" were left behind.*

In New South Wales, as in America, gold has been found in association with bismuth and tellurium, as well as with copper pyrites and arsenical pyrites, iron pyrites, antimony, zinc, lead, &c.

(*b*) GOLD ASSOCIATED WITH BISMUTH AND TELLURIUM, AND IN SOME CASES COMBINED WITH THEM.—At Mount Shamrock, in Queensland, gold is largely associated with bismuth and tellurium. In the parish of Jingera, County Murray, near Captain's Flat, New South Wales, Mr. J. C. H. Mingaye, F.C.S., Assayer and Analyst to the Department,† discovered that tellurium was present in considerable quantity associated with the bismuth, and combined with it in the form of tetradymite.

At Kingsgate also, near Glen Innes, gold is found in association with the the bismuth, some samples of this metal assaying as much as 3 oz. of gold per ton.

In the case of the gold-bearing bismuth ores which have come under my notice, from Queensland in particular, I have been unable in most cases to see metallic gold in the native bismuth, though it is observable in abundance in the oxidised coating which invests the latter. This would seem to imply that the gold thus associated is usually alloyed with the bismuth.

Dr. J. Storer, however, has presented the Mining and Geological Museum of the Department of Mines, Sydney, with a specimen of native bismuth, showing free gold enclosed in the former metal, from the Eidsvold Gold-field of Queensland; and a similar enclosure of gold in metallic bismuth is reported to have been observed at the Kingsgate Mine, Glen Innes. No systematic search has so far been made for the possible presence in small quantities of bismuth and tellurium in the gold-bearing sulphide ores of N. S. Wales, the occurrence of these two metals having been recorded chiefly when they were present in some considerable quantity. Bismuth has been proved by analyses made by Mr. W. A. Dixon, F.I.C., F.C.S., to be present in most cases in the copper ores of the Great Cobar Copper Mine. Samples analysed by him in 1878 yielded from ·21 to 2·66 per cent. of metallic bismuth, and the refined copper from the ore containing ·419 per cent. of bismuth. Although this copper contained 8 oz. of silver per ton, Mr. Dixon's analyses show that traces only of gold were present, a fact which proves that bismuth ores in New South Wales are not always gold-bearing. The discoveries of Sandberger that bismuth is occasionally present in hornblende from the more recent eruptive rocks, and also generally in lithia-mica, shows the probability of its being a somewhat widely distributed metal, and both it and tellurium may yet be found to be present in minute quantities in the gold ores of New South Wales in many more instances than are at present known; and in such cases, the gold will no doubt be alloyed with the bismuth and tellurium, obviously a very important factor to be determined in connection with the subsequent treatment of such ores.

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* Analyses made by Professor Liversidge and Dr. Leibus of the alluvial golds from various parts of New South Wales show that the quantity of copper present is inappreciably small as compared with that of the silver, which seems to show that silver has a greater affinity for gold than copper has, the silver varying from 1 to 33 per cent. and the copper from traces to ·27 per cent.

† Report Austr. Assoc. Adv. Sci. for 1888 [1889], I, p. 116; Records Geol. Survey N. S. Wales, 1889, I, pt. 1, p. 26.

(*c*) GOLD ASSOCIATED WITH ARSENICAL PYRITES AND ARSENIC, AND POSSIBLY COMBINED WITH ARSENIC.—The existence of arsenide of platinum, and the practical experiments of Mr. Pearce upon the artificial production of an arsenide of gold, considered in conjunction with the well-known fact that gold exudes in the form of "moss gold" from arsenical pyrites, when the latter mineral is heated at a temperature below the ordinary fusion point of gold, render the occurrence in nature of such a compound not only possible, but probable.

Gold occurs in association with arsenical pyrites in a great number of gold veins in New South Wales, as for instance at the New Reform Mine, Lucknow, where it is also associated with native arsenic; at Sunny Corner; at the Prince William Mine, Ironbarks, near Orange; the Star of Peace Mine, Hill End; Mandurama, &c. According to assays by Professor Liversidge, F.R.S.,* a sample of arsenical pyrites from the Prince William Mine, Ironbarks, near Orange, yielded by assay—

	oz.	dwt.	gr.
Gold	213	19	8 per ton.
Free Gold	4	11	3 „
Silver	0	9	3 „

The small quantity of silver as compared with the gold in this case proves that the gold was not to any appreciable extent combined or alloyed with the silver, and unless it was in some state other than that of free gold, it is difficult to understand why only about two per cent. of the whole gold present was capable of being extracted by amalgamation. This fact is somewhat in favour of part of the gold being present as arsenide, and if the latter be true it will have a very important bearing upon the probable volatility of any gold so combined, as will be explained in the sequel.

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* Ann. Report Dep. of Mines N. S. Wales for 1875 [1876], p. 161.

(*d.*) GOLD ASSOCIATED WITH COPPER PYRITES, AND PERHAPS COMBINED WITH COPPER.—The presence of gold in copper ores in New South Wales has been proved by several analyses and assays made by this department. In the Annual Report of the Department of Mines for 1875,* Professor A. Liversidge gives returns as follows of three samples of copper ore assayed by him from Mitchell's Creek :—

Sample 31, containing visible gold. Gold, 1 oz. 2 dwt. 20 gr. per ton; percentage of metallic copper, 9·48.

Sample 32, containing visible gold. Gold equal to 4 oz. 10 dwt. 8 gr. per ton; percentage of metallic copper, 9·48.

Sample 33, red oxide and green carbonate of copper. Contained gold equal to 14 oz. 10 dwts. 6 grs. per ton; per centage of metallic copper, 25·79.

In the last case there is no mention of any visible gold.

Again, in the Annual Report for 1882,† an analysis by Mr. J. C. Watt, of copper ore from the Monaro District, shows gold to be present at the rate of 2 oz. 19¼ dwts. per ton; silver at the rate of 18 oz. 15½ dwts. per ton; the percentage of metallic copper being 27·4 per cent. In this case the gold may have been alloyed with the silver instead of being combined with the copper.

The discovery, by Mr. Pearce, that in the case of copper mattes containing bismuth and silver, gold is combined with the copper, and not with the silver nor with the bismuth, suggests the possibility that in cases where several pyritous gold-bearing ores are present, such as those of arsenical pyrites, iron pyrites, magnetic pyrites, and copper pyrites, the bulk of the gold may be contained in the copper pyrites. If this is the case, the richness in gold of many "slimes" may easily be explained by the well-known tendency of copper pyrites, on account of its brittle nature, to pass into slime during pulverisation. At Sunny Corner, for instance, and at Mandurama, at the Junction Mines, all the pyritous ores above mentioned are present; but it is not yet known, I believe, which of them carries most gold. and this question, with regard to the latter mine in particular, is one of vital importance as relating to the question of the most suitable machinery for the concentration of its sulphide ores.

With regard to the gold-bearing pyritous ores of New South Wales it would appear to me that, if the gold in the ore be alloyed at all, it is as probable that it is alloyed with minute quantities of copper, as that it is alloyed with bismuth and tellurium. If, however, some of the golds of New South Wales have ever been alloyed with copper when present in sulphide ores, it must have been the case that during the natural process of oxidation in the upper parts of the veins, the copper has been parted from the gold by oxidation, as no samples of natural gold contain copper to any great extent, so far as at present known. It has been stated that some of the Bingera gold contains a certain amount of copper, but my Colleague, Mr. G. A. Stonier, Geological Surveyor, who has recently consulted Mr. Heywood, of the Mint, on this subject, informs me that the foreign metal associated with the Bingera gold is iridium, and not copper.

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* p. 144. † p. 16.

The following analyses made at the Royal Mint, Sydney, show that the Bingera gold, which is popularly supposed to contain a good deal of copper, is almost wholly composed of gold and silver:—

Bingera gold.	Gold.	Silver.	Total.
A17,892	·9090	·085	= ·994
921	·9230	·070	= ·993
18,006	·9135	·080	= ·9935
226	·9140	·075	= ·989
390	·9145	·080	= ·9945
461	·9210	·070	= ·9910

In the case of the copper pyrites at the Junction Mine, near Mandurama, Mr. Hogue, the manager, states that his experiments show that the gold at this mine is present chiefly in the magnetic pyrites, rather than in the arsenical and iron pyrites, and copper pyrites.

The results of the samples selected from this mine, and assayed by Mr. J. C. H. Mingaye, show that traces only of gold are to be detected in the magnetic and in the iron pyrites, each of these minerals having been isolated and assayed separately. The arsenical pyrites and copper pyrites have yet to be isolated and assayed, and the result of these last assays may throw important light on this question.

(*e*) GOLD ASSOCIATED WITH STIBNITE AND METALLIC ANTIMONY.—Gold occurs associated with metallic antimony at the New Reform Mine, Lucknow, and with stibnite at several gold-bearing reefs in the Hillgrove District, including the Eleanora Reef, and Baker's Creek, in the Macleay District, and at the Lunatic Gold-field. At the New Reform Mine, the relation of the gold to the metallic antimony is well shown in a piece of ore from here, which Mr. C. S. Wilkinson has had cut and polished, and which shows the gold to be present unalloyed in the form of small particles of irregular shape from $\frac{1}{40}$ to $\frac{1}{20}$ of an inch in diameter imbedded in the native antimony, and also as interstitial films in cracks in the latter.

In the sulphide of antimony of the Hillgrove District, Mr. G. A. Stonier informs me that the gold appears to be present in three forms:

(1) As native gold, very fine.

(2) As pale native gold, the gold being evidently alloyed with some other metal.

(3) As gold rust.

A specimen of the sulphide of antimony lately presented to the Mining and Geological Museum by Mr. Moses, of Armidale, shows gold to be present in patches or minute vughs in the stibnite in the form of a very finely divided ochreous powder. Minute quantities of quartz are in most cases associated with it, though in places the gold powder is slightly isolated from the quartz, and is thoroughly intermixed with the delicate prisms of the stibnite round the edges of the small cavities. This gold rust presents the appearance of a dull ochreous brown powder, but can readily be burnished, so as to show a bright metallic lustre.

A sample of pure stibnite selected by Mr. C. S. Wilkinson, from the Eleanora Reef in 1883, and assayed by the Department's Assayer, yielded—

Fine gold at the rate of 2 ozs., 12 dwts. per ton.
„ silver „ „ 19½ dwts. „

A sample of stibnite from the Macleay District assayed at the Department of Mines, gave—

Gold—3 dwts. 6 grs. per ton.
Silver—traces.

Other associations of gold in gold-bearing ores in New South Wales, and the loss of gold which results from the roasting of sulphide ores, in which gold is associated, alloyed, or combined with some volatile element, will be discussed in a subsequent paper by the Author in the next part of this publication.

[*To be continued.*]

XVII.—Analyses of Samples of Cokes, manufactured from various Coke-producing Coals in the Northern, Southern, and Western Coal Districts of N. S. Wales: by J. C. H. MINGAYE, F.C.S., Analyst and Assayer.

I.—Introduction.

THE bulk of the enormous amount of coke consumed in smelting operations in the Broken Hill District, about one thousand three hundred and ten tons, per week, is imported from England.

The following figures are supplied by Mr. William Knox, the Secretary of the Broken Hill Proprietary Company's Mine, as to the quantity consumed per week for smelting operations:—

	Present requirements.	Estimated future requirements.
Broken Hill Proprietary Company	550 tons.	800 tons.
British Broken Hill Proprietary Company	350 ,,	450 ,,
Broken Hill Proprietary Block 14 Company	170 ,,	170 ,,
Broken Hill Junction Silver-mining Company	80 ,,	160 ,,
Australian Smelting and Refining Company	160 ,,	160 ,,
	1,310 tons.	1,740 tons.

The Broken Hill Proprietary Company also furnish the following figures as to the cost of the various descriptions of coke delivered at Port Pirie:—

	Average cost per ton.		
English coke, 18,144 tons	£3	7	8
German coke, 2,750 tons	2	19	6
New Zealand coke, 2,000 tons	2	17	6
New South Wales coke, 4,880 tons	2	13	6
British Broken Hill Proprietary Company—English coke, 10,581 tons	3	4	4

Information regarding analyses of the coals from the different Coal-fields of New South Wales, will be found in the *Mineral Products of New South Wales*, published by the Department of Mines, also in the *Minerals of New South Wales*, by Professor Liversidge, M.A., F.R.S.

Ash.

Prof. Liversidge states in *The Minerals of New South Wales, &c.*, as follows:—"The northern coals yield from 2·7 per cent. to 11·51 per cent. of ash, with an average of 6·80 per cent.; the Western district coals range from 6·24 to 12·91 per cent., and average 9·73 per cent. The Southern district coals, omitting the samples which seem to be somewhat exceptional in character, yield from 4·41 per cent. to 18·52 per cent., and average 10·01 per cent. of ash.

Sulphur.

	Number of specimens.	Average percentage of sulphur.
Northern coal-fields	42	·88
Western ,,	25	·73
Southern ,,	27	·76

I found it almost impossible to strike an average of the amounts of ash in the coals, analyses of which were made in the Laboratory, as in most cases the samples were taken by prospectors from exposed outcrops, and, therefore, did not represent a true average; and in few cases were samples received from working collieries. On comparing the average percentage of ash with that of the English coals it will be noticed that it is much higher, although the New South Wales Northern coal compares favourably with the German, American, and French coal. As regards the presence of sulphur, the coals of New South Wales are exceptionally free from that element, and I think will, without doubt, compare in this respect with coal in any part of the world.

By direction of the Hon. the Minister for Mines and Agriculture, I conducted the following investigations regarding cokes made from the coals of the Southern, Western, and Northern Districts of New South Wales, with a view of ascertaining their suitability for metallurgical purposes.

II.—Cokes of the Northern District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
1. Rix's Creek, Singleton	1·328	·63	·36	87·81	10·67	·54
2. Coke used in Laboratory for fuel	1·313	1·24	3·31	85·68	12·35	·42
3. Coke made from unwashed coal, Thornley Colliery, East Maitland	1·267	·10	·30	88·70	9·83	1·07
4. Co-operative Colliery, Wallsend	1·308	·41	·21	87·36	11·50	·52
5. Purified Coal & Coke Co., Newcastle	1·339	·31	·46	90·88	7·93	·42
Average	1·311	·538	·328	88·086	10·456	·594

No. 1 (966).—This coke was "hard burnt," received in pieces measuring about one foot eight inches long. Blackish-grey in colour, dense, and hard. It should be readily handled without breaking or crumbling, and bear a heavy burden. Throughout the coke were visible pieces of a hard shaly material, some of which had burnt white. In parts the coke was coated with thin layers of ferrosoferric sulphide. Ash: yellowish tinge, flocculent.

No. 2.—Average sample of the coke supplied to the Laboratory for fuel.—Blackish-grey in colour; in length, measuring more than a foot. In most pieces large fissures were visible, running along the entire length of the pieces. Coated in thin layers with ferrosoferric sulphide, which exhibited the characteristic play of colours, dense, and fairly hard. This coke was not "hard burnt," and although it should bear handling without crumbling, is not so good a sample as the former one for smelting purposes. Ash: reddish tinge, with white specks, flocculent, and fairly free from heavy grit. A trace of lead and copper was detected. An examination of a large quantity of the ash was made for gold and silver, with the result that neither of these metals were detected.

No. 3 (1548).—Made from unwashed coal, Thornley Colliery, East Maitland.—Coke, firm and bright, with a silvery metallic lustre, in pieces measuring over one foot in length. This is a good description of coke, and should readily stand handling without breaking or crumbling, and bear the weight of a heavy burden; "hard burnt." Ash: buff-coloured, flocculent; contains a large proportion of a hard siliceous substance, the bulk of which could have most probably been removed by washing the coal before coking. A test for copper, lead, gold, and silver, gave negative results.

No. 4 (1885).—Co-operative Colliery, Wallsend.—Blackish-grey, inclined to silvery, dense, and hard. In pieces measuring over one foot six inches in length; "hard burnt." Hair-like threads were observed in this coke, occurring in patches somewhat resembling fibre. This coke should readily stand handling without breaking or crumbling, and bear the weight of a heavy burden. Ash: yellowish in colour, flocculent. The ashes containing a fair proportion of a hard gritty substance. A test for copper and lead gave negative results.

No. 5 (2057).—Purified Coal and Coke Company, Newcastle.—Coke, silvery and metallic in appearance, dense and compact. In pieces measuring over one foot in length; "hard burnt." This sample can be readily handled without breaking or crumbling, and should bear the weight of a heavy burden of flux and ore. An excellent coke for metallurgical operations. Ash: yellowish in colour, flocculent; contains many pieces of a hard gritty substance. An examination of a large quantity of the ash was made for the presence of gold and silver, with the result that neither of these metals were detected.

III.—Cokes of the Western District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Cullen Bullen Coal Co. Second experiment, washed before coking...........	1·716	5·30	1·92	74·06	18·20	·52

Only one sample was received from the Western District.

No. 1 (1479).—Coke, dull in colour, honeycombed, and not extra firm, pieces not in very large lengths. A very poor quality of coke, the ashes containing a very large amount of silica. The moisture in this sample is exceptionally high; this may probably be due to water having been used to cool the coke after coking Through the coke large pieces of a hard siliceous substance were visible, showing that the washing operations had not been a success. Ash: almost white in colour, granular, dense. About one-third of the ash consists of hard siliceous grit. A minute trace of copper was detected.

IV.—Cokes of the Southern District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Bulli Coke Works. Stated to have been made from washed coal	1·469	1·53	·79	83·77	13·45	·46
Wollongong Coke Works............	1·566	·26	·29	87·75	11·27	·43
Undanderra ,, ...	1·471	1·35	·73	83·92	13·41	·59
Coke from Moss Vale	1·400	....	1·35	79·20	19·00	·45
Coke from Wollongong........	1·503	·52	....	84·60	14·36	·53
,, ,, ...	1·454	·53	....	86·05	12·83	·59
Average	1·477	·698	·525	84·21	14·05	·508

No. 1 (892).—Bulli Coke Works, stated to have been made from washed coal.—Coke, fairly bright, blackish-grey in colour, very dense and hard; should stand readily handling without breaking, and will bear the weight of a heavy burden. On examining the sample, pieces of a hard shaly substance were visible through the coke. Ash: light-grey in colour, dense. A strong trace of lead and copper was detected. An examination of a large quantity of the ash for gold and silver failed to detect either of these metals.

No. 2 (893).—Wollongong Coke Works. Coke prepared from unwashed coal.—The same remarks apply to this coke as to the physical appearance of No. 1. The sample contains less ash than the former one. Ash: buff-coloured, dense. A minute trace of lead and copper was detected.

No. 3 (894).—Undanderra Coke Works.—Coke blackish-grey in colour, dense, and very compact. Throughout the coke, many pieces of hard, shaly matter were visible. From its hardness, this coke can be readily handled without breaking, and should stand the weight of a heavy burden of ore and flux. Ash: light-grey in colour, contains a large proportion of a heavy grit. A trace of copper detected. An examination of a large quantity of ash for the presence of gold and silver gave negative results.

No. 4 (905).—Coke from Moss Vale, made from unwashed coal.—Coke, fairly well swollen-up, fine and lustrous. Ash: white in colour, granular. The coal from which this coke was made yielded, on analysis, as follows:—

	Proximate analysis.	
Hygroscopic moisture	2·28	
Volatile hydrocarbons	33·07	
Fixed carbon	52·22	Coke, 64·65 %
Ash	12·43	
	100·00	

Specific gravity, 1·362.
Sulphur in coal, ·590 %

No. 5.—Mount Kembla, Wollongong.—Bright and firm, blackish-grey in colour. It can be handled without readily breaking, and should stand the weight of a heavy burden of ore and flux. Ash: light-grey in colour, contains a large proportion of grit, dense. A trace of copper detected.

No. 6.—Coke from Wollongong.—The same remarks apply to this sample.

V.—*Summary of Analyses of New South Wales Coke.*

Locality.	Fixed Carbon.	Ash.	Sulphur.
New South Wales—			
Northern District	88·09	10·45	·594
Southern District	84·21	14·05	·508
English	91·56	6·55	1·260
American	90·13	8·68	·685

The following analyses are furnished, showing the composition of the ashes of the cokes:—

NORTHERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Sesquioxide of iron.	Manganese (Mn. O.)	Lime.	Magnesia.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.	Total.
1	Rix's Creek, Singleton	10·67	56·07	31·57	7·47	..	2·38	trace.	·72	·06	·22	·23	99·62
2	Coke used in Laboratory for fuel.	12.35	56·26	28·33	11·52	·27	1·00	·16	1·27	·04	·67	·82	100·34
3 4	Made from unwashed coal Thornley Colliery, East Maitland.	9·83	57·66	30·33	9·06	strong trace.	·65	·23	1·50	trace.	·64	·19	100·25
5	Co-operative Coal Company.	11·50	59·64	34·56	2·62	trace.	·75	1·13	1·26	·04	·30	·12	100·42
	Purified Coal and Coke Company.	7·93	51·20	34·33	9·14	do	2·63	·55	·19	·54	1·80	Nil.	100·38
	Average	10·456	56·16	31·82	7·962	·054	1·482	·414	·988	·316	·726	·272	..

WESTERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Oxide of iron.	Manganese (Mn. O.)	Lime.	Magnesia.	Potash.	Soda.	P_2O_5	$S.O_3$	Total.
1	Cullen Bullen Coal Company	18·20	80·20	17·25	trace.	trace.	1·68	·18	1·10	trace.	trace.	trace.	100·41

SOUTHERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Sesquioxide of iron.	Manganese.	Lime.	Magnesia.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.	Total.
1	Bulli Coke Works..........	13·45	53·84	36·79	2·53	strong trace.	2·29	1·62	1·44	·02	·30	·68	99·51
2	Wollongong Coke Works ..	11·27	55·24	39·67	1·75	do	1·28	trace.	·97	·38	·67	·29	100·25
3	Unanderra do ..	13·41	55·49	39·60	1·11	do	1·72	·15	1·09	·46	·51	·24	100·37
4	Coke from Moss Vale	19·00	69·75	23·83	3·17	trace.	1·00	·45	·33	·45	trace.	·31	99·29
	Average	14·282	58·58	34·97	2·14	..	1·572	·555	·957	·327	·370	·380	..

VI.—*Phosphoric Acid.*

The ashes of the coals of New South Wales yield much less phosphoric acid than the English, which is greatly in their favour when the coals or cokes are required to be used for iron-smelting purposes.

	No. of Samples.	Maximum.	Minimum.	Mean.
New South Wales—				
Northern District..............................	5	1·800	·22	·726
Southern District..............................	4	·670	trace.	·370
*Western District	8	·640	trace.	·290
Great Britain	6	6·633	·74	1·843

VII.—*General Remarks.*

For further information regarding the composition of the ashes of New South Wales coals, I would refer to the various analyses made by Professor Liversidge and Mr. W. A. Dixon, F.C.S.†

A coke required for metallurgical purposes should exhibit the following physical appearances:—Blackish-grey in colour, with a more or less fatty lustre, in that prepared from coals rich in oxygen, to a light iron-grey, with a fine silky or almost metallic lustre, the coke yielded by coking coal often resembling in structure a mass of melted slag or lava. A good description of coke should be uniform throughout, without any great admixture of fibre or shaly matter, also dense and compact. The coke should be "hard burnt" so as to exhibit the latter quality, and therefore be capable of resisting the action of the blast. Coke of this quality carries twice the burden of flux and ore.

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* Minerals of New South Wales, &c., by Professor Liversidge.

† Minerals of New South Wales, &c., pp. 140–141.

The objection to the uses of the New South Wales cokes at Broken Hill seems to be the excessive amount of ash present in the samples over the cokes manufactured from the British coals and elsewhere, the ash being useless material, besides hindering the combustion of the coke. As an example, a coke yielding ten per cent. of ash would represent ten tons of useless material in every one hundred tons of coke, which freight would have to be paid for.

The ash in the northern cokes averages in five samples 10·45 per cent., one of the samples yielding only 7·93 per cent., which is little more than one and three-quarters per cent. higher than the average given of seventeen samples of English coke. I refer to that manufactured by the Purified Coal and Coke Co., Newcastle, which, as regards its physical appearance and make, is an excellent description of coke. Nos. 1, 3, and 4 are good descriptions of coke, they being well made in long lengths, "hard burnt," and capable of standing the pressure of a heavy burden of ore and flux.

Professor Liversidge gives the mean of forty-two analyses of the ash in the coals of the Northern District as 6·80 per cent., thirteen of the samples yielding under five per cent. of ash. I venture to think that the amount of ash present in the northern coals could be greatly reduced, at a comparatively low cost, by a thorough system of grinding, screening, and washing the " slacks" before coking; especially in those coals yielding four, five, and six per cent. of ash.

The western coals, as a rule, do not yield a good description of coke. The coals often only coking when freshly obtained from the pit. The amount of ash present is usually high compared with the ashes of the Northern District, though lower than the Southern. The samples received from the Southern District all yielded high results for ash, and in one or two cases, the samples furnished were stated to have been washed before coking; if this is the case, it is very evident that the washing machines, if properly worked, are not suitable for this class of coal. In most of the samples many pieces of hard shaly matter were visible, and the ashes contained a large amount of a heavy gritty substance. The cokes were well burnt, very dense and compact, and would be a good description of coke for metallurgical purposes if containing less ash.

The whole question as to the uses of our cokes for metallurgical purposes at Broken Hill and elsewhere, hinges on the amount of ash present, and suggests a systematic and thorough method of sorting, screening, and washing the coals before coking, so as to obtain an article as free from ash as possible. From experiments made in the Laboratory, on the small scale, it was found possible to greatly reduce the amount of shaly matter in the coal by screening and washing. As information should prove useful as to the cost of washing and coking, also the description of washing-machines and ovens in use in Great Britain and the Continent, I venture to furnish the following, obtained from some of the best authorities on the subject. In France the cost is given as follows:—

	d.
Labour	5·1
Other Charges	1·2
Loss	8·3
Total	14·6

Or about 1s. 2d. per ton of washed coal, while on a produce of sixty-six per cent. of coke would cost 1s. 10d. per ton of coke.

Michworth's purifier.—These machines are used in Scotland, Cumberland, Derbyshire, Wales, to purify from twenty to one hundred tons of coal per day, at a cost not exceeding threepence per ton, and with a loss not exceeding 2·0 per cent. of coal.

The Bochum Mining and Smelting Co., in Westphalia, in order to obtain a pure coke for their blast furnaces, established at their collieries a complete set of apparatus for working the coal on the Lührig system. It is stated by them that one thousand tons of coal can be washed in this machine. Before washing, the coal contained eight per cent. of ash; after washing, 3·6 per cent of ash. The cost of washing is given at less than one half-penny per ton of coal. The cost of handling being less in Great Britain and the Continent, of course, a liberal allowance will have to be added for treatment of the New South Wales coals. Many other descriptions of washing-machines are used, those on the hopper-dredge system being largely in use, and are stated to perform excellent work.

The Coal is usually coked in ovens of the bee-hive pattern, there being a very great variety of ovens in use, each of which claim their respective qualities.

In America, cokes containing seven, nine, ten, and eleven per cent. of ash are used for smelting purposes; the coke made at the Broadford Works contains from nine per cent. to nearly twelve per cent. of ash. At Rockwood, Roane Co., Tennessee, a coal is coked for use in the blast furnaces containing 5·27 per cent. to 11·52 per cent. of ash. A coke made in Colorado, and used principally by the lead smelters in cupolas, &c., contains from 6·6 per cent. to 7·15 per cent. of ash.

In conclusion, I may point out that the coals of New South Wales, though higher in ash than the average of British coals, would be greatly improved in quality as regards the ash present, by a thorough systematic method of washing before coking, especially the northern coals, which form excellent coke.

XVIII.—Note on Mr. J. C. H. Mingaye's Analyses of N. S. Wales Coals and Cokes: by T. W, EDGEWORTH DAVID, B.A., Geological Surveyor.

I WOULD venture to summarise the conclusions drawn by Mr. Mingaye in this interesting and valuable Report on the composition of the coke manufactured in New South Wales, and that of their ashes, and to supplement these with a few remarks.

The results of these analyses show fairly well probably the relative values of the cokes of the different districts represented by the samples sent. While, however, the Newcastle Series of the Northern Coal-field and the Southern Coal-field were tolerably well represented, only one sample was received from the Western Coal-field (and this too was very imperfectly purified), none were received from the Tomago, nor from the Greta Series of the Northern Coal-field, and none from the Gunnedah Coal-field. The results of these analyses are not, therefore, indicative of the values of all the cokes that are, or can be produced in New South Wales, though they may be taken to be representative of the most important coke-producing mines.

The coals of New South Wales belong, so far as at present known, to five distinct formations, which occur in the following order, the oldest and lowest in the series being placed first:—

(1.) Rhacopteris Beds, developed principally in the Stroud District.—Contain a few seams of dirty, unworkable coal, from a few inches up to four feet thick.

(2.) Greta Coal-Measures.—Contain valuable coal-seams, which, however, do not form a good coke.

(3.) Tomago Coal-Measures.—Contain productive coal-seams, some of which form a fair coke, and, in the case of the Rix's Creek measures (if they are to be referred to this series), a very good coke.

(4.) The Newcastle, Bulli, and Rix's Creek (?) Coal Measures.—Contain valuable productive coal-seams, which form a very good coke, except in the case of some of the seams of the Western Coal-field, which either do not coke, or lose their coking properties upon exposure.

(5.) Clarence Coal Measures.—Contain productive seams, from which a fair coke is manufactured, at Ipswich and Burrum, in Queensland, but hitherto no workable seams have been discovered in these measures in New South Wales.

Mr. Mingaye's Report shows that the cokes manufactured from the Newcastle and Rix's Creek seams are probably superior for smelting purposes to the cokes of the Southern and Western Coal-fields, at any rate so far as percentage of ash is concerned.

The coke made by the Purified Coal and Coke Company, Newcastle, heads the the list in this respect, containing only 7·93 per cent. of ash, a return of which compares favourably with the average amount of ash present in the cokes of Europe and America. Rix's Creek coke is not far behind, with 10·67 of ash.

The cokes made from the Bulli Seam, in the Southern Coal-field, are a trifle higher in ash than those of Newcastle and Rix's Creek; but it would perhaps be invidious to assume that they are therefore of less value for smelting purposes, taken as a whole, than the Newcastle and Rix's Creek cokes; for no doubt the exact state of the fixed carbon in a coal has much to do with the value of the coke produced from it, the fixed carbons in different cokes not necessarily having cent for cent a uniform value.

It is worthy of note that in one case here the coke made from the unwashed coal was proved to contain more ash than that made from coal stated to have been purified by washing. As however Mr. Mingaye points out, the washing in this case had been very imperfectly carried out, as evidenced by the presence of fragments of clay shale in the coke.

The sample of coke forwarded from the Western District exhibited similar evidence of having been imperfectly purified.

As regards their ashes, those of the New South Wales cokes are more siliceous, and, consequently, more refractory than those of the cokes of Europe and America, and contain less lime and iron; but on the other hand, are freer from phosphorus and sulphur than either of the preceding.

Mr. Mingaye's general conclusion is that, with increased care in the manufacture, especially with regard to the washing appliances used in purifying the coal for making coke, cokes can be produced in New South Wales equal in every respect, probably, to those imported from Europe and America, except with regard to the more refractory nature of the ash in the first-named, a defect, however, which is partly compensated for by their greater freedom from such deleterious elements as sulphur and phosphorus. It is to be hoped that this systematic research into the suitability for smelting purposes of the cokes of New South Wales, instituted by the Honorable the Minister for Mines and Agriculture, will be the means, not only of calling attention to the value of the article now produced, but will also lead to improvements being made in its manufacture by calling attention to the present defects.

XIX.—*Lepidodendron australe*, M'Coy—Its Synonyms and Range in Eastern Australia: by R. ETHERIDGE, JUN., Palæontologist and Librarian.

I.—Introduction.

WE are indebted to Mr. William Carruthers, F.R.S., &c., for the first description of an Australian *Lepidodendron*, in his paper, "Notes on Fossil Plants from Queensland, Australia[*]," wherein is described the plant referred by the author to *Lepidodendron nothum*, Unger, a species characteristic of the Upper Devonian beds of Thuringia. For the second description of a species of this genus we are similarly indebted to Sir F. M'Coy, F.R.S., &c., who in 1874 furnished a full diagnosis[†] of his long before named[‡] *L. australe*, from the Lower Carboniferous rocks of the Avon River, Gippsland, Victoria. Mr. Carruthers assigns the supposed *L. nothum* from Queensland to the "Old Red Sandstone," the localities given by the late Mr. R. Daintree being Mount Wyatt, Canoona, and the Broken River.[§] Prof. O. Feistmantel,[||] who has twice described both species, accepts M'Coy's determination of the Gippsland *Lepidodendron* and its horizon, and follows Carruthers in his views of the identity and age of the form found in Queensland. He further records the occurrence of the latter in New South Wales.

The reference of an Australian *Lepidodendron*, however, to the age of the Devonian has not passed unchallenged, for Prof. M'Coy questions[¶] the identity of the supposed *L. nothum* from Queensland, as described by Carruthers, with the European species of the same name; and Mr. Robert Kidston, an acknowledged authority on the genus *Lepidodendron*, distinctly disagrees with such a view, both as expressed by Carruthers and Feistmantel. Prof. M'Coy considers the Queensland plant as probably identical with the Victorian, whilst Mr. Kidston[**] places the former as a synonym of the latter. It is contended by the Writer that the two are one and the same plant, and should be known as *Lepidodendron australe*, M'Coy.

II.—Previous Knowledge of Lepidodendron *in Australia.*

It is but fair to a number of the earlier Australian Geologists to point out that the occurrence of *Lepidodendron* was known some time before Sir F. M'Coy's Avon River species came to light, in what was then, geographically speaking, N. S. Wales, notwithstanding that the statements of the various authors in question appear to have been looked upon as "reports that have at times been circulated as to the occurrence of a *Lepidodendron* in the Australian coal-beds."[*]. The expression "coal-beds" must be taken in a wide or family sense, as including the whole series of Carboniferous beds, not merely the Coal-Measures.

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[*] Quart. Journ. Geol. Soc., 1872, XXVIII, p. 353.

[†] Prod. Pal. Vict., 1874, Dec. I, p. 37, t. 9.

[‡] Victorian Exhibition Essays, 1861, p. 163.

[§] Quart. Journ. Geol. Soc., 1872, XXVIII, p. 289.

[||] Since this was written we have received the sad news of Prof. O. Feistmantel's death.

[¶] Prod. Pal Vict., 1874, Dec. I, p. 38.

[**] Cat. Pal. Plants Brit. Mus., 1886, p. 231.

As early as 1848, the late Rev. W. B. Clarke, F.R.S., &c., recorded[†] *Lepidodendron* from the shales of the Manilla River, and on the Namoi and Gwydir Rivers, from the grits and sandstones of the Paterson River, and from the hard siliceous metamorphic rocks of Colocolo, on the Allyn River, associated with Brachiopoda and trilobites. The first figure of an Australian *Lepidodendron*, is, I think, that given in one of the much-overlooked Reports of the late Samuel Stutchbury, the first Government Geologist of New South Wales. In his "Tenth Tri-monthly Report on the Geological and Mineralogical Structure of New South Wales," dated Berrigal, July 1st, 1853,[‡] containing a description of the Liverpool Plains, and Valley of the Horton River, a cast of a *Lepidodendron* is given. It was discovered in "argillaceous shales and sandstones," presumedly, from the context, at the crossing place over the Oaky Creek, four miles from Cobedah. Although the figure is merely in outline, the species is unmistakably *L. australe*, M'Coy, in all its characters. Stutchbury remarks, "Having found several specimens of *Lepidodendron* in the argillaceous shales and sandstones, and believing that they have not hitherto been figured as occurring in the Australian coal measures, I take this opportunity of doing so, for the purpose of calling attention to these important extinct vegetable remains." In 1855 Mr. F. Odernheimer's survey of the Peel River District revealed the presence of *Lepidodendron* in soft slate, associated with metamorphosed rocks of that neighbourhood.[§] The next year (1856) Mr. J. S. Wilson announced the discovery of this plant at Goonoo Creek, near Tamworth, but he did not give any definite information regarding its horizon there[‖]. A full list of localities where *Lepidodendron* had been found up to 1861, was given in that year by the Rev. Mr. Clarke,[¶] inclusive of Goonoo, and a further discovery at Canoona, on the Fitzroy River, in Queensland.

In another paper Clarke summarised[**] these various discoveries, and further remarked, "In 1849 I requested the late Admiral P. P. King to take with him to England some additional New South Wales fossils. Among them was a supposed Lepidodendron, found by my late friend Leichhardt, about seventy-five miles from the coal-beds of Mount Wingen. . . . . . . Since that time

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[*] W. Carruthers, Quart. Journ. Geol. Soc., 1872, XXVIII, p. 350.

[†] On the Genera and Distribution of Plants in the Carboniferous System of New South Wales.—*Quart. Journ. Geol. Soc.*, 1848, IV., p. 60.

[‡] N. S. Wales Legislative Council Papers, 1853, 235 A, p. 9 (f'cap, Sydney, 1853).

[§] On the Geology of Part of the Peel River District, in Australia.—*Quart. Journ. Geol. Soc.*, 1855, XI., p 399.

[‖] Notes on the Geology of the Neighbourhood of Sydney, Newcastle, and Brisbane.—*Quart. Journ. Geol. Soc.*, 1856, XII, p. 283.

[¶] On the Relative Position of certain Plants in the Coal-bearing beds of Australia.—*Quart Journ. Geol. Soc.*, 1861, XVII, p. 354.

[**] On the Age of the New South Wales Coal-field. *Ann. Mag. Nat. Hist.*, 1862, X, p. 81.

Mr. Stutchbury and myself collected such *Lepidodendra* abundantly, as may be seen by reference to our Geological Reports." Mr. Clarke subsequently stated[*] that the plant conveyed to England by Admiral King was, he was informed by Prof. M'Coy, *Lepidodendron tetragonum* of the English Coal-fields, an opinion supported by that eminent botanist, the late Sir Charles Bunbury.

These quotations and references will show, tolerably well, the conditions under which *Lepidodendron* was known to the pioneers of Geology in Eastern Australia previous to the discovery of M'Coy's *L. australe*; and the original remarks of the authors quoted, one would have thought, would have been sufficiently clear to render unnecessary any clearing up of reports "that have at times been circulated as to the occurrence of a *Lepidodendron* in the Australian coal-beds."[†]

III.—Lepidodendron australe *and* L. nothum.

The essential points of M'Coy's description of the former species are the rhombic leaf-scars with straight thick boundaries, the vascular scars small, and oval or rounded, placed either in the middle, or towards the upper angle of the scars, and in each connected with a vertical, rounded, shallow sulcus. M'Coy's Fig. 1*a* shows these characters in relief, with the vascular scar central, and Fig. 1*b* the same with an apical scar.[‡]

As we are not acquainted with either the leaves or fruit of *L. australe*, M'Coy, the only portion of Mr. Carruthers' description of his *L. nothum* with which we are concerned, is the following passage:—"Scars of the leaves contiguous, rhombic, with a single and generally central vascular scar." In his casual remarks the author states that the form of the leaf-scar varies much from pressure, but when not thus affected is rhombic. Two variations are shown in Carruthers' Pl. 26, Figs. 13 and 14.[§] The scar of the vascular bundle is generally present, but not always;[¶] when present it is sometimes central,[‖] at other times apical,[**] or again gives rise to a "longitudinal impression extending from nearly the bottom to the top of the scar."[††]

Prof. O. Feistmantel has twice described both *L. australe* and *L. nothum* as separate species, but we need concern ourselves only with the views expressed by his second diagnosis.[‡‡] Of *L. australe*, he remarks that the leaf-scars are rhombic, with thick boundaries, the vascular cicatrices small, and oval or rhombic, rarely near the middle, more commonly at the upper angle of the scar, with a shallow median sulcus. Of *L. nothum*, he merely quotes Carruthers' description.

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[*] Sedimentary Formations of N. S. Wales, Third Edition—*Mines and Min. Statistics N. S. Wales*, 1875, p. 160.

[†] W. Carruthers, Quart. Journ. Geol. Soc., 1872, XXVIII., p. 350. The "circulation," by-the-bye, of all but one paper, took place in the same eminently scientific Journal as Mr. Carruthers' paper appeared in.

[‡] Prod. Pal. Vict. 1874, Dec. I, t.9, f.1,*a* and *b*.

[§] Quart.'Jour. Geol. Soc., 1872, XXVIII, p. 353. The question of the identity of *L. nothum* with *L. gaspianum*, or *Leptophlœum*, having no bearing on the present discussion, is not referred to here.

[¶] Carruthers, *loc. cit*. Pl. 26, Fig. 12.

[‖] Carruthers, *loc. cit*. Pl. 26, f. 10.

[**] Carruthers, *loc. cit*. Pl. 26, f. 8 and 11.

[††] Carruthers, *loc. cit*. Pl. 26, f. 9.

[‡‡] Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p.p. 136–138.

The foregoing are simply facts derived from each author; we may now enter on the points for and against the identity of these two supposed species. The evidence is simply taken from their descriptions, my own observations made from the specimens now in our Collection being left until later. One point, however, must be clearly understood—none of the present remarks are intended to apply to *Lepidodendron nothum*, Unger, the European fossil, but simply to *L. nothum*, Carr., the supposed Australian plant.

In the first place the form of the leaf-scar in both is admittedly rhombic, varying slightly in degree, according to the amount of pressure the plant had undergone; and both M‘Coy and Feistmantel agree in describing that of *L. australe* as with straight thick boundaries, which are also visible on some of Carruthers' figures of *L. nothum*.[*] The vascular scar in both is single, central or apical in *L. nothum* (Carruthers); near the middle, or towards the upper angle in *L. australe* (M‘Coy); rarely near the middle, but more often towards the upper angle in *L. australe* (Feistmantel); and in *L. nothum* the last named author has in contradistinction to Mr. Carruthers, only seen the vascular scars in the upper angles of the leaf-scars. The vascular scars in *L. australe* are often connected with a shallow longitudinal sulcus (M‘Coy); showing in the middle a shallow sulcus (Feistmantel) or, in *L. nothum* giving a longitudinal impression extending from nearly the top to the bottom of the scar (Carruthers). Now, the question may be asked, what points of difference between *L. australe* and *L. nothum* does this comparison show? Simply one, viz.:—That in *L. nothum*, Feistmantel has seen the vascular scars only in the upper angles of the leaf-scars; but Carruthers says, that they are central or apical! Yet *L. australe* and *L. nothum* are held to be distinct species. If, therefore, any difference exists between them it must lie in the leaves or fruit, but with neither of these are we acquainted in *L. australe.*

Prof. M‘Coy refers his species to that section of the genus *Lepidodendron* known as *Bergeria*, Presl.,[†] and in this he is followed by Dr. Feistmantel, who quotes the opinion of Prof. Solms-Lauback in support.[‡] But Dr. Feistmantel also places *L. nothum*, Carr., in *Bergeria*;[§] and from certain remarks make by Mr. Carruthers on the relation of *L. nothum* to Coal Measure *Lepidodendra*, I am inclined to believe that he thought so also.[¶] So far, therefore, both so-called species are referred by their respective describers to the same section of the genus. Prof. M‘Coy furthermore regards both *L. australe* and *L. nothum*, Carr., as closely related to the European Carboniferous *L. tetragonum*, Sternb. He remarks thus,* "Anyone comparing Mr. Carruthers' or my figures with that of Sternberg's *Lepidodendron tetragonum* . . . will find that the identity is so close, that for what I have figured as a variety or species under the special name *L. australe*, I only suggest the general slightly longer form of the scars as possibly distinctive." And, as a corollary to this, may be quoted his remark, "I do not see any reason for supposing it [*i.e.*, *L. australe*] referable to the little Devonian *Lepidodendron nothum* (Unger)."

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[*] Carruthers, *loc. cit.*, t. 26, f. 10 12.

[†] Prod. Pal. Vict., 1874, Dec., I, p. 37.

[‡] Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales, Pal., No.* 3, p. 137.

[§] *Loc. cit.*, p. 138.

[¶] Quart. Journ. Geol. Soc., 1872, XXVIII, p. 354.

Speaking of the *Lepidodendron* previously referred to (*L. tetragonum*) as taken to England by the late Rear-Admiral King, Mr. Clarke says,† "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales and Queensland, and from the latter Colony it was also brought in abundance by Mr. Daintree. Mr. Carruthers, who has given its description fully in the paper before alluded to (Q.J.G.S., August, 1872), has assigned to it the name of a species described by Unger, viz, *Lepidodendron nothum*." Now this is a very important passage, for it proves two things—1st, that others besides McCoy had recognised the resemblance of our Australian fossil to *L. tetragonum*, and 2nd, the identity of *L. nothum*, Carr., with the plant (*L. australe*) likened to *L. tetragonum*, in the estimation of Mr. Clarke. On the other hand, Dr. Feistmantel states, ‡ because *L. australe* is allied to *tetragonum*, therefore the former "can in no way be co-related with *L. nothum*, Ung., from New South Wales and Queensland." It may of course be contended that the opinion of the late Mr. Clarke, through the latter not being a Botanist or Palæontologist, was of little weight in such a discussion; but Mr. Clarke had through long years of training become a very astute observer, and I may therefore, I think, range him on the side of those who failed to see any reason for the splitting of our commonest *Lepidodendron* into two species.

Mr. Kobert Kidston takes a very decided view of the mutual relations of *L. australe* and *L. nothum*, Carr. He remarks,§ "The plant figured and described as *Lepidodendron nothum* by Mr. Carruthers (which, however, is not Unger's species of that name) appears to be indistinguishable from *Lepidodendron Australe*, McCoy."

IV.—*Notes on Specimens.*

I have assembled for examination as many specimens as possible, both from New South Wales and Queensland. The New South Wales localities represented are—Cedar Creek, near Cox's River; Back Creek, Barrington Gold-field; Clear Creek, near Glanmire; Oaky Creek, west of Cobbodah; Goonoo Goonoo, near Tamworth; Boora

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* Prod. Pal. Vict., 1874, Dec., I, p. 39.

† Sedimentary Formations of N. S. Wales—Third Edition.—*Mines and Mineral Statistics of N. S. Wales*, 1875, p. 160.

‡ Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales*, *Pal. No.* 3, p. 137.

§ Cat. Pal. Plants Brit. Mus., 1886, p. 231.

Creek, thirty-nine miles north-west of Tamworth; Doctor's Creek, near Bingera; Tarella Creek, near Barraba; Manilla River, Sowton's Mountain Paddock, near Barraba; Bindogundra, near Bumberg Ranges, west of Molong; Grenfell Road, four miles from Cowra (presented by the Rev. J. Milne Curran). The plants from these, as well as the Queensland localities, including the Great Star River, are of course in various states of preservation, but in a very large proportion the thick boundary ridges of the leaf-scars are visible just as shown in Mr. Carruthers' illustrations, and McCoy's figures of *L. australe.* The rhomboidal leaf-scars are either transversely or vertically elongated, and vary greatly in size, as the following measurements will show:—

Transversely elongated—6 x 4, 4 x 3, 8 x 6, 5 x 4, 6 x 5.
Vertically elongated—4 x 3, 6 x 7, 4 x 3.
Equilateral—6 x 6, 2½ x 2½, 4 x 4.

Out of the seventy odd specimens examined, fifty-seven showed no trace of a vascular scar on the leaf-scar, thus resembling Carruthers' Fig. 12[*], and some of those given by Feistmantel,[†] nor vertical groove or ridge, according as the specimens were reliefs or impressions. Twelve only presented the vascular cicatrix in the upper angle of the leaf-scar, and two alone displayed the vertical ridge extending downwards from the position of the former without its presence.

In the specimens from Corner Creek, Great Star River, the vascular scars are apical; and the leaf-scars transversely elongated with thick margins.

V.—Comparison with L. nothum, *Unger.*

Unger's general figure[‡] represents a small stem of the natural size, about four inches long, by from three to four-eighths of an inch wide. The leaf-scars vary, as represented on the figure, from one to one and a quarter millimieters, and we are asked to consider the Australian *Lepidodendron*, with its noble proportions as identical with this. In the words of Prof. McCoy, "all the figures of the Devonian species mentioned,[§] indicate the much smaller, more numerous, and much more acute, longitudinally elongate leaf-scars as constant characters; together with a central vascular cicatrix." I may add that the latter is the rarest position for the vascular scar to occupy in our Australian species, and as regards the size of the leaf-scars, the measurements previously given speak for themselves. Prof. M'Coy further remarks.[||] "Mr. Carruthers refers a plant from Queensland, which probably is identical with ours, to the Devonian *L. nothum*; but I know of no reason for considering the Gympie beds Devonian; the great balance of the palæontological evidence, in my opinion, indicating rather the Lower Carboniferous age, and, as I have said, of our Victorian plant, I think of the Gympie one,[*] that the scars are so much larger and fewer on approximately the same sized branches, that it is not desirable to make such a reference."

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[*] Quart. Journ. Geol. Soc., 1872, XXVIII., t. 26. f. 12.

[†] Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.– *Mem. Geol. Survey, N. S. Wales, Pal. No.* 3, t. 2, f. 1, 2.

[‡] Denksch. K. Akad. Wien., 1856, XI, t. 10.

[§] Prod. Pal. Vict., 1874, Dec., I., p. 38.

[||] *Ibid*, p. 38.

Again, Sir William Dawson has recently replied to Mr. Carruther's criticisms on certain plants described by him. Speaking of *Leptophlœum rhombicum*, Sir William remarks,[†] "Some confusion has been introduced into the position of this species by the identification with it on the part of Dr. Carruthers of a very different plant obtained in Queensland by Mr. Daintree. This is perhaps not to be wondered at, since the Queensland plant belongs to a type of Lepidodendron characteristic in America of the Lower Carboniferous, and of which *L. tetragonum* of Sternberg is the representative. This plant had been discovered in the Carboniferous of Victoria by Dr. Selwyn, long before it was found in Queensland, in beds supposed to be Devonian. Specimens from Mr. Daintree's collection shown to me by Mr. Carruthers, and others in the collection of Dr. Selwyn, leave no doubt as to this. . . . . Still further to complicate matters, this Australian *Lepidodendron* was not only identified with *Leptophleum rhombicum*, but with the entirely distinct species *Lepidodendron Gaspianum*, and with *L. nothum* of Unger."

The comparison made, and extracts given, will have prepared the reader for the opinion I have formed, viz., that omitting the question of leaves and fruit, there is no specific difference between *Lepidodendron australe*, M'Coy, and *L. nothum*, Carr. (*non* Unger). If Mr. Carruthers[‡] is correct in laying down the axiom, "that the position of the scar, and the presence of a furrow introduced by Dr. Dawson into diagnosis of the genus and species are of no value," how can the two plants be separately retained? No service is rendered to Australian stratigraphical geology by the definite reference of any of its fossils to European species, unless on the clearest possible evidence, and I consider the reference of this widely distributed Australian species to *L. nothum*, Unger, as against the balance of evidence, and committed in the first instance, through an entire ignorance of Australian geological literature.

VI.—The Horizon of L. australe *in Victoria.*

Prof. M'Coy states that *L. australe* is found in the Carboniferous Sandstones of the Avon River, five miles above Bushy Park, Gippsland,[§] and it was certainly known to him as early as 1861.[¶] Dr. Feistmantel states that the Avon Sandstone

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[*] I think Sir F. M'Coy is wrong here. So far as I know, no *Lepidodendron* has been found at Gympie.

[†] The Fossil Plants of the Erian (Devonian) and Upper Silurian Formations of Canada, Part 2, 1882 (Geol. Survey Canada, 8vo., Montreal, 1882), p. 105.

[‡] Quart. Journ. Geol. Soc., 1872, XXV., p. 352.

[§] Proc. Pal. Vict., 1874, Dec., I., p. 39.

[¶] Victorian Exhibition Essays, 1861, p. 163.

"rests unconformably on the upturned edges of true Devonian rocks with characteristic fossils."[*] This statement appears to be taken from Tenison-Woods,[†] who makes use of exactly the same words, he, in his turn, deriving the facts from M'Coy[‡]. Selwyn and Ulrich, in describing[§] the Avon beds, make no mention of an unconformity between them and the Devonian; nor does Mr. Alfred Howitt, in his masterly paper, "Notes on the Devonian Rocks of North Gippsland," wherein he remarks,[||] speaking of the Upper Devonian, "We may observe that these conditions continued into the Carboniferous age, and it would seem, as in other parts of the world, with an apparent passage from one formation to the other." Finally, Mr. R. A. F. Murray writes[¶] on this subject as follows:—"From my own observations, I am inclined to believe that the beds in which it [*i.e.*, *L. australe*] is found are among the uppermost of the group, and younger than, though conformable with, the Upper Devonian beds of Freestone and Iguana Creeks. It is highly probable, therefore, judging from their stratigraphical position, that the Avon Sandstones are—as indicated by Professor M'Coy, on palæontological evidence—of Lower Carboniferous age, or passage beds in that direction upwards from the Upper Devonian beds." It may, therefore, I believe, be accepted that *L. australe* is, speaking broadly, of Carboniferous age in Victoria.

VII.—Horizon of L. nothum, *Carr., in Queensland and New South Wales.*

QUEENSLAND.—The first intimation of a Devonian *Lepidodendron* in Queensland is due, so far as I know, to my lamented friend, the late Richard Daintree, C.M.G., although, as I have previously pointed out, not the first announcement of the discovery of the genus in that Colony. It was the plant now known as *L. nothum*, (Unger) Carr. The statement occurs in his "General Report upon the Northern District,"[**] and the following extracts will pretty well show the unsatisfactory evidence upon which his first opinion was based:—"Next, in the descending order of stratified rocks, are the probable equivalents of the 'Devonian' of English Geologists. . . . . . . The lowest beds in the series are clay-slates and conglomerates, succeeded by massive coralline limestones. The uppermost strata are of a more sandy character. In these upper sandstones the best-preserved fossils are met with. *Lepidodendron* is the chief representative of the flora, associated with a fauna containing in great abundance *Spirifer disjunctus*. As the latter is an Upper Devonian type in Europe, whilst the former ranges from Upper Devonian to the top of the Carboniferous, it would seem to favour the view taken of this formation, and that *Lepidodendron* is here confined to the upper portion of this Devonian series. The slates and limestones of Rockhampton may be taken as representatives of the Lower Devonian, and so called "The Rockhampton Series"; . . . . the sandstone and shales of Mount Wyatt, as Upper Devonian, and called "The Mount Wyatt Series." These being provisional, the value of the division to be tested by the careful collection and determination of the contained organic remains hereafter."

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[*] Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales, Pal. No.* 3, p. 137.

[†] Proc. Linn. Soc. N. S. Wales, 1884, VIII., p. 134.

[‡] Prod. Pal. Vict., 1874, Dec., I, p. 38.

[§] Phys. Geogr. Geol. and Min. of Victoria—Intercol. Exhib. Essays Vict., 1866., p. 15.

[||] Geol. Survey Vict., Report of Progress, 1876, No. 3, p. 237.

[¶] Victoria—Geol. and Phys. Geogr., 1887, p. 67.

[**] Q'land Leg. Assembly Papers, 1870.

On first reading this Report, it is somewhat difficult to grasp to what series of rocks Daintree referred as the "Rockhampton Series." If to the fossiliferous rocks so largely developed around that town, and having for one of their principal localities the Training-wall Quarries on the Fitzroy River, then "careful collection," such as the successful labours of the late Mr. James Smith, will have completely exploded at least a portion of the above classification. The fossils obtained by Mr. Smith have demonstrated the series referred to by me, to be of Permo-Carboniferous age, and identical with rocks of that age so largely developed in New South Wales. But the further context of Daintree's Report does not seem to bear out this idea, rather that, under the above name he included those now regarded by Mr. R. L. Jack and myself as of Middle Devonian age, and distinguished as the Burdekin beds. As regards the association of *Lepidodendron* with *Spirifera disjuncta*, I am of course unable to prove that such is *not* the case in this particular instance, but I think it very *improbable.* During the ten years I have been in the habit of examining Queensland organic remains on behalf of the Geological Survey of that Colony, I have never seen *Spirifera disjuncta* from within its geographical boundaries, much less associated with *Lepidodendron.*

Mr. Daintree continued—"For a hundred miles of longtitude, and forty of of latitude, shales, coralline limestones, and *Lepidodendron* sandstones are repeated again and again at the surface in a series of syn—and anticlinal axes. . . . The only other sedimentary strata in tropical Queensland, whose place on the geological horizon has been determined by palæontological evidence, are a series of blue and grey slates and shales around Mount Wyatt. On the upturned edges of these rest the slightly inclined grits and sandstones of the Upper Devonian *Lepidodendron* beds. Specimens from this locality presented by me several years ago, to the Melbourne Museum, determined by Professor M'Coy, consisted of *Chonetes sarcinulata*, *Orthis* allied to *rustica*, *Receptaculites*, *Lepætna* sp. undetermined; and were referred by that authority to the 'Upper Silurian' of English geologists. The outcrop of these Silurians is very limited round Mount Wyatt."

With regard to the last paragraph quoted, it is clearly perceptible that Daintree did not intend to imply that *Lepidodendron* was associated with the other fossils mentioned. The latter came from the "blue and grey slates and shales," underlying unconformably the Lepidodendron beds, and have been relegated by Mr. R. L. Jack*, and correctly so, I think, to the Burdekin Group. But in connection with the Lepidodendron beds a peculiar conclusion is forced upon us by this aspect of the case. Litttle doubt can exist that the shales, coralline limestones, and Lepidodendron sandstones, which are "repeated again and again at the surface," are portions of the Burdekin Group; and so are the "blue and grey slates and shales," containing the supposed Upper Silurian fossils named by Prof. M'Coy. If, therefore, the stratigraphy described by Daintree is to be accepted with the light of our present palæontological knowledge, we have Lepidodendron beds unconformable on Lepidodendron beds.

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* Handb. Q'land Geology, Col. and Indian Exhib. Essays, 1886, p. 23.

In his Memoir, published two years later, Daintree adds to Mount Wyatt, the further localities of Canoona and Broken River, as those at which *Lepidodendron* is found, and the plant is definitely stated, on the authority of Mr. Carruthers, to be *L. nothum*, Unger, of the European Devonian rocks. Any corroborative evidence of this is certainly not there advanced by Mr. Daintree, notwithstanding the following passage[*], "At Mount Wyatt the plant-beds are interstratified with strata containing Spirifers, &c.; and as these are fully described in the Appendices to this paper, no further mention of them is required here." Unfortunately for this statement not a single *Spirifera*, or other Invertebrate, is described from either of the three localities previously mentioned as yielding *Lepidodendron*. On the other hand, there is just the possibility that Mr. Daintree referred to the Gympie Spirifers, then considered Devonian. If so, the case for the Devonian age of *Lepidodendron nothum*, Carr., is made all the worse, because the Gympie fauna is now admitted to be Carboniferous, as suggested both by Prof. M'Coy,[†] and the late Rev. W. B. Clarke[‡] (or more properly speaking, Permo-Carboniferous), an opinion I have held in common with these authorities for some time.

The only evidence known to me, which can be adduced in support of Daintree's reading of the Mount Wyatt geology, is a remark by the late Rev. W. B. Clarke, when speaking of the fossils sent by him to the late Prof. L. G. de Koninck[§]. "The fossils . . . from Yass, Mount Lambie, and on the Turon and Moruya Rivers, and which are in part identical with the the Mount Wyatt shells in Queensland." On following up this evidence, however, we again meet with disappointment, for on referring to De Koninck's work[¶] but a single species is described from Mount Lambie—the only locality in New South Wales where *Lepidodendron* is said to be associated with Devonian fossils—and that is *Rhynchonella pleurodon*, more a Carboniferous than a Devonian shell. Nor are we enlightened on this point in the most recently issued work on Queensland Geology, Mr. R. L. Jack's "Hand-book." On Mount Wyatt, Mr. Jack simply quotes Daintree's remarks from the Northern Report previously given. Of

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[*] Quart. Journ. Geol. Soc., 1872, XXVIII, p. 289.

[†] Prod. Pal. Vict., 1874, Dec., I, p. 38,

[‡] Sedimentary Formations of N. S. Wales. Third Edition.--*Mines and Min. Statistics N. S. Wales*, 1875, p. 159

[§] *Ibid*, p. 158.

[¶] Foss. Pal. Nouv. Galles du Sud, 1876, Pt. 2, p. 96.

Canoona, he affords no information whatever; but of the Broken River locality, the Queensland Government Geologist observes, "it may be surmised that the Lepidodendron beds occur in a horizon equivalent to that of the Star beds, and separable from the beds which have yielded the corals described by Mr. R. Etheridge, Senior."[*] Canoona is also referred to by the Rev. W. B. Clarke, who remarks,[†] "At Canoona Gold Field, in Queensland, Lepidodendron occurs in hardened shales," but not a word about any associated Devonian fauna. Beyond, therefore, Mr. Daintree's statement, that the strata yielding *Lepidodendron* at Mount Wyatt, are interstratified with *Spirifera disjuncta* beds, the presence of a Devonian *Lepidodendron* in Queensland rests on the most contradictory and unsatisfactory statements, unsupported by other evidence. Notwithstanding this we find Dr. O. Feistmantel unhesitatingly committing himself to a Devonian age for the *Lepidodendron*.[‡]

In December, 1882, the late Rev. J. E. T. Woods brought under the notice of the Royal Society of N. S. Wales, the occurrence of a Flora containing *Lepidodendron* (*L. veltheimianum*), and *Calamites* on the Central Queensland Railway at Bobuntungen, and referred it to the age of the "lower coal formation of Europe," *i.e.*, Carboniferous.[§] In the same year Woods recorded also the presence of the disputed *L. nothum* in the same beds, remarking, "It was found on the Drummond Range, at the end of the central railway."[||] In the stratigraphical portion of his Memoir on the "Coal Flora," he again places these *Lepidodendra* under the Lower Carboniferous, mentioning as localities, "Canoona River, Broken River, and Mount Wyatt." Notwithstanding this, however, the Rev. Author had but a few months before cited *L. australe*, *L. nothum*, and other plants from the Devonian, with precisely the same array of localities.[¶]

In another publication Mr. Woods speaks of the Drummond Range formation, "which by its fossil plants (Lepidodendron, Calamites), &c., most certainly belongs to the lower Carboniferous of Europe."[**] Again, a still further expression of opinion was made in August, 1883, in a "Report on Coal on the Central Railway,"[††] to the Secretary of Lands, Brisbane, in which, after enumerating the Bobuntungen fossils, he says, "All well known European forms of the lower coal flora." The continued reiteration of his opinion clearly speaks for itself, in so far as the age of these plants is concerned.

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[*] Handb. Q'land Geology, Col. and Indian Exhibition, 1886, p. 41. The corals were described by Prof. H. A. Nicholson, M.D., and R. Etheridge, Jun.

[†] Sedimentary Formations of N. S. Wales, Fourth Edition, 1878, p. 25, *note*.

[‡] Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal.*, *No.* 3, 137.

[§] Journ. R. Soc. N.S. Wales for 1882 (1883), XVI, p. 179.

[||] Proc. Linn. Soc. N.S. Wales, 1884, VIII. p. 135.

[¶] Journ. R. Soc. N.S. Wales for 1882 (1883), XVI., p. 189.

[**] The Coal Resources of Queensland, p. 26 (8-vo., Brisbane, 1883).

[††] The Queenslander, 1883, XXIV., No. 414, p. 396.

Some years ago Mr. R. L. Jack submitted to me a collection of Carboniferous fossils from the basin of the Great Star River,[*] a stream formed by tributaries of the Upper Burdekin River. Amongst these were several examples of the so-called *L. nothum*, and since then others have been obtained from the same area by Mr. P. N. Pears, lately Warden of the Ravenswood Gold-field.[†] Although in the early days of his investigations, the Canoona and Broken River localities,—from whence *L. nothum* was recorded by Daintree, be it remembered—were accepted by Mr. Jack as Devonian, he now seems to think that they may be on the same horizon as the Great Star River beds, and those of the Drummond Range.[‡]

It will be remembered that the Rev. Mr. Woods recorded *L. nothum* from the Drummond Range, a statement which appears to be accepted by Feistmantel[§]; at any rate, he does not controvert it. If the species has so preponderating a Devonian significance, its presence at that locality should be allowed to exercise a more or less similar influence, but, on the contrary, the Drummond Range rocks are by one and all set down as Lower Carboniferous.[||]

Such appears to be the main distribution of *L. nothum*, Carr, in Queensland, as at present known, the chief points to be borne in mind being—(1) that it does not differ in structure from the *L. australe* of the Victorian Lower Carboniferous; (2) that the balance of evidence points out a similar horizon rather than a Devonian one.

N. S. WALES.—Let us now examine the corresponding distribution of this plant in our own Colony.

I believe the late Rev. W. B. Clarke was the first to apply a name to the N. S. Wales *Lepidodendron*, as *L. tetragonum*, as early as 1851, on the authority of Prof. M'Coy. His words were,[¶] "In June, 1851, Professor M'Coy wrote to me from Cambridge, respecting the first Lepidodendron he had seen from Australia, and which I had forwarded by the late Rear-Admiral King to Professor Sedgwick, and stated it to be *L. tetragonum* of the English coal-fields." He added likewise, "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales and Queensland, and from the latter Colony it was also brought in abundance by Mr. Daintree." In an earlier edition of the Memoir from which these extracts are taken, Mr. Clarke spoke as follows on the general question:—"So far as Lepidodendron is concerned, that plant occurs in some places in association with beds that are decidedly younger than any called

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[*] Report on the Geology and Mineral Resources of the District between Charters Towers Gold-fields and the Coast, by R. L. Jack, p. 10 (fcap, Brisbane, 1879).

[†] Jack, Handb. Q'land Geology, Col. and Indian Exhib., 1886, pp. 39 and 40.

[‡] Handb. Q'land Geology, Colonial and Indian Exhib., 1886, p. 40.

[§] Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., 1890—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p. 138.

[||] *Loc. cit.*, p. 55.

[¶] Sedimentary Forms. N.S. Wales. Third Edition.—*Mines and Min. Statistics N.S. Wales*, 1875, p. 160.

Devonian, near Pallal, on the Horton River, and on the Manilla River, in Liverpool Plains. . . . . . and at Goonoo Goonoo, on the Peel River, in New South Wales, it occurs in fine grey sandstone with Ferns and Sigillaria, in close proximity to beds of marine fossils which are certainly Lower Carboniferous."[*] The localities here mentioned will be found in Pars. I. and IV., as amongst those at which *L. nothum*, Carr., has been found, so that no doubt can exist as to the species referred to by Mr. Clarke. The Rev. Gentleman appears to have been the first in 1875 to record *L. nothum*, by name, as a New South Wales fossil, and to show its extent over a wide area.[†] His remarks were, "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales." The only locality mentioned by name is the Mount Lambie Range, near Rydal, "where the Devonian Brachiopoda occur." In 1878, Dr. Feistmantel added two further localities, Goonoo Goonoo, on the Peel River, and the Back Creek Diggings, Barrington River.[‡] In the Fourth Edition of the "Sedimentary Formations," Clarke supplemented the above important statement by announcing that in 1876-77, he had ascertained the position of *L. nothum*, Carr., to be considerably below the Brachiopod Sandstone of Mount Lambie.[§] On the other hand, Mr. C. S. Wilkinson places [||] the Lepidodendron bed above the sandstone with Brachiopoda. In 1882 he wrote as follows:—"The lower beds, which form the summits of Mount Walker and Mount Lambie, consist of sandstones and quartzites with numerous fossils, chiefly *Spirifer disjunctus*, and *Rhynchonella pleurodon*; while above these are shales, slates, and quartzites containing *Lepidodendron nothum*." This statement was repeated in the second edition of the "Notes"[¶] published in 1887. The other and unpublished localities at which *L. nothum*, Carr., has been obtained in New South Wales, and of which specimens are extant, will be found in Par. IV. In the English edition of his "Palæozoic and Mesozoic Flora of Eastern Australia," Dr. Feistmantel gives as further localities for *L. nothum*, Carr., Cowra and Canowindra, on the Lachlan River; and, relying on Mr. Clarke's account of the Mount Lambie deposits, considers the plant wholly of Upper Devonian age. To his remarks the following editorial foot note was appended in the work just quoted,[**] "The passage referred to here in Mr. Clarke's 'Sedimentary Formations of New South Wales' is, on the first reading a somewhat misleading one. The expression 'below the level,' must not be taken in a stratigraphical sense, but simply as indicating a lower position as regards the conformation of the ground. The Government Geologist distinctly wishes it to be understood that the *Lepidodendron* in question occurs in beds *above* the Brachiopod Sandstone of Mount

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[*] Sedimentary Forms. N.S. Wales. Second Edition.—*Cat. Nat. Industrial Prods. N.S. Wales, Paris Univ. Exhib.*, 1867. *App.* p. 71. (8vo., Sydney, 1867.)

[†] Sedimentary Forms. N.S. Wales. Third Edition.—*Mines and Min. Statistics N.S. Wales*, 1875, p. 160.

[‡] Pal. Mes. Flora Ost. Australiens.—*Palæontographica*, Suppl. Bd. iii, Leif 3, 1879, Heft. 4, p. 142.

[§] Sedimentary Forms. N.S. Wales. Fourth Edition, 1878, p. 22.

[||] Notes on the Geology of N. S. Wales (Dept. Mines, N.S. Wales), 1882, p. 42.

[¶] Notes on the Geology of N.S. Wales. Second Edition. (Dept. Mines, N. S. Wales), 1887, p. 57.

[**] Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No. 3.*, p. 36 *note.*

Lambie, he having been present with the late Rev. Mr. Clarke when the observations were made. . . . . ." This is confirmed by another short description of Mount Lambie given by Mr. Wilkinson[*] in 1875, wherein he states that the Lepidodendron beds are about one hundred feet thick, and occur one thousand feet above the Spirifer Sandstone. Now, admitting the latter to be Devonian, the only point which tends to place the Lepidodendron beds within the same formation is the conformability of the latter to the former, although at a height of one thousand feet above. But is this of greater importance than the equivalent conformability which exists between the Upper Devonian beds in Gippsland and the Avon Series with *L. australe*, which are admittedly Carboniferous?

On a previous page a quotation was given from Mr. Clarke's writings, in which he refers to the association of *Lepidodendron* with beds "decidedly younger than any called Devonian," such as the Manilla River; and at Goonoo Goonoo, "in close proximity to beds of marine fossils which are certainly Lower Carboniferous." A reference to Par. IV, containing a list of the localities from which we now possess *L. australe*, will show that both of these are there included, and herein we have additional evidence for the Carboniferous age of the *Lepidodendron* in question. The reference to Goonoo Goonoo is the more important because Dr. Feistmantel has made the following statement[†] in connection with the so-called *L. nothum*, Carr:—"According to the available literary sources, this fossil comes from beds which have to be considered of Upper Devonian age, at least with regard to the geological sequence in New South Wales, where the Goonoo beds underlie the *Lepidodendron* beds of Smith's Creek, Stroud, which themselves are Lower Carboniferous."

That the Smith's Creek plant-beds may be of the age mentioned is, I think, probable; but I must confess myself entirely ignorant of the literary sources from which the position of the Goonoo Goonoo beds is deduced. Little or nothing seems to be known of their definite relations to the surrounding rocks, and even Mr. D. A. Porter, of Tamworth, who has long studied the geology of that district, assured me that he had failed, so far, to solve the question.

VIII.—Conclusion.

In the foregoing summary of the facts relating to *L. australe*, M'Coy, and *L. nothum* Carr. (non Unger), I have endeavoured to bring forward all the information relating to the age of these plants within my power, whether for or against the Devonian hypothesis. The facts which have been advanced from time to time to sustain this seem to be inadequate for the purpose—simply with our present knowledge, be it understood—and I think it will be better to suspend judgment until more is known of the geology of the districts in question.

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[*] Mines and Min. Statistics of N. S. Wales, &c., 1875.—*N. S. Wales Intercolonial and Philadelphia Internat. Exhib.* (8vo., Sydney, 1875), p. 133.

[†] Coal and Plant-bearing Beds of Palæozoic and Mesozoic age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p. 138.

If the conformable transition described by Mr. Howitt, between the Upper Devonian and Carboniferous of Gippsland is of general occurrence throughout Eastern Australia, it will perhaps be convenient to adopt the presence of this *Lepidodendron* as the artificial line of demarcation between the two great series which are presumed to represent portions of the Devonian and Carboniferous Formations of other parts of the world. On the other hand, it is of course possible that a detailed survey of the Mount Lambie and Mount Wyatt areas in New South Wales and Queensland respectively, may show that the Lepidodendron beds are an integral part of the Devonian series there said to exist. In such a case *L. australe* can only be looked upon both as a Devonian and Carboniferous species, for it most certainly occurs with a Carboniferous fauna in the Great Star Basin in Queensland (see Par. IV). But, presuming that such be the case at Mount Lambie, the latter occurrence only shows how preposterous it is to assume that Devonian rocks exist at every locality from which the species is quoted under the misapplied name of *L. nothum*, Unger, when practically nothing is known of their detailed geology. The preparation of comparative tables of Australian Stratigraphy on such evidence as this is not only of doubtful value, but is also misleading. Indeed, I think I may cite this question as evidence strongly in favour of the remarkably philosophical arguments used by my friend Mr. R. M. Johnston, in his paper on "The Order of Succession of the Characteristic Genera of Fossil Plants of a Far Distant Region, &c.,"* in which he pleads against the belief that the community or resemblance of organic remains in rocks of far distant regions indicates strict contemporaneity, and I believe, in a broad general way, with great success.

The following deductions can, I think, be drawn from the remarks made in previous pages:—

1. A *Lepidodendron* occurs in Victoria, N. S. Wales, and Queensland in beds either of Upper Devonian or Lower Carboniferous age, or both, specifically identical.
2. Of the two names applied to this species, *L. australe*, M'Coy, in Victoria; and *L. nothum*, Carr., in N. S. Wales and Queedsland, the former should be adopted.
3. *L. australe* appertains to the section *Bergeria*, and is allied to *L. tetragonum*, Sternb., of the European Coal-Measures.
4. The horizon of this plant in Victoria is generally accepted as Carboniferous.
5. *L. australe* occurs in the basin of the Great Star River, Queensland, associated with a Carboniferous fauna.

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* Proc. Austr. Assoc. Adv. Sci. for 1888 [1889], I, p. 302.

6. The Drummond Range rocks, in which this plant is said to occur by the late Rev. J. E. T. Woods, are Carboniferous.

7. With the exception of Mount Lambie in N. S. Wales, and Mount Wyatt in Queensland, no direct evidence exists for considering the beds developed at the various localities as Devonian.

8. The evidence for assuming a Devonian age to the Mount Wyatt beds containing *Lepidodendron* is as present unconfirmed, and unsatisfactory.

9. At Mount Lambie there appears to be an insensible gradation, *so far as our present knowledge shows*, from beds of Upper Devonian age into those of Lower Carboniferous, as in Victoria.

10. We have no tangible evidence of the commingling of a *Lepidodendron* and a Devonian fauna, as we have of *L. australe* and a Carboniferous at the Great Star River.

11. The resemblance of *L. australe* to a European Coal-Measure species, *L. tetragonum*, Sternb., and a Lower Carboniferous American form, as noted by Dawson, and related to *L. tetragonum*, is strong presumptive evidence of the Carboniferous age of the first-named, supposing, *i.e.*, we are to adopt, or endeavour to adopt, a European classification for our Upper Palæozoic rocks.

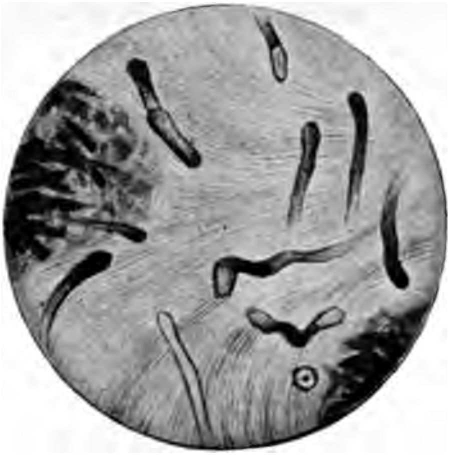
PLATE VII.

Fig. 1. Tubes of *Palæachlya tortuosa*, Eth. fil. Small portions of the tubes permeating the substance of a Monticuliporoid Coral from the Permo-Carboniferous of Queensland.

Fig. 2. Massed tubes of *Palæoperone endophytica*, Eth. fil., and black spherical bodies from the interior of the corallites of *Stenopora crinita*, Lonsdale. Permo-Carboniferous of Wollongong, N. S. Wales.

Fig. 3. Tubes of the same, with pin-shaped upper terminations, from the same locality. One of the tubes carries within it five of the spherical bodies serially arranged.

From drawings by Mr. G. H. Barrow, Australian Museum, all highly enlarged.



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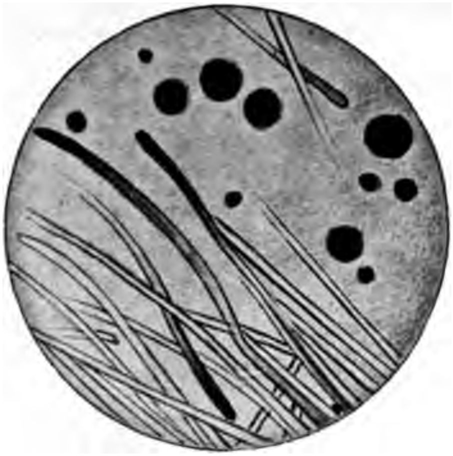

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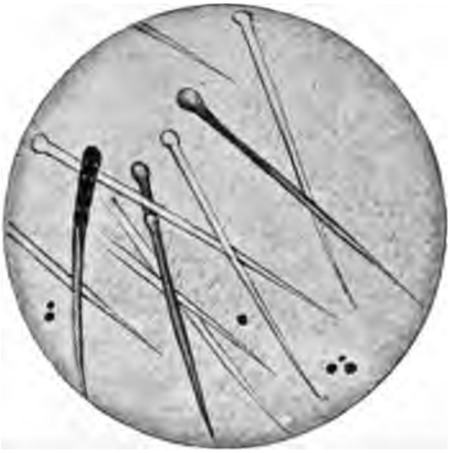

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CATALOGUE OF MINING MAPS

PUBLISHED BY THE

DEPARTMENT OF MINES, SYDNEY, NEW SOUTH WALES,

1st JANUARY, 1889.

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1s. per sheet is the uniform price.

ALBERT MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Albert	**Yancowinna** ..	**Thackaringa.**	**Mount Gipps**	**Yancowinna** ..	**Silverton.**
Alma	do	**"The Pinnacles."**	**Moorkaie**..............	do ..	do ... **Mount Gipps.**
Alberta	**Farnell**........	**Corona.**	**Naradin**	do ..	do
Bomangaldy............	**Yancowinna** ..	**Silverton.**	**Purnamoota**	do ..	do
Bray	do	do	**Picton**	do ..	do **Broken Hill.**
Bolaira	do	**Silverton, Round Hill.**	**Robe**..................	do ..	do **Purnamoota.**
Bligh	**Farnell**........	**Corona.**	**Stephen**	do ..	do
Badjerrigarn	do	do	**Soudan**................	do ..	do
Byjerkerno	do	**Poolamacca.**	**Sebastopol**	do ..	do **Rockwell Paddock.**
Corona	do	**Corona.**	**Tara**	do ..	do .. **Piesse's Nob.**
Edgar................	**Yancowinna** ..	**Silverton.**	**Umberumberka**	do ..	do
Fowler's Gap (see Giles)..	**Farnell**........		**Wankeroo**	do ..	do
Giles	do	**Fowler's Gap.**	**Yancowinna**	do ..	do
Lewis	**Yancowinna** ..	**Silverton.**			

BATHURST MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Bolton (a)	**Westmoreland**..	**Wiseman's Creek.**	**Jocelyn**	**Westmoreland**..	**Wiseman's Creek.**
Baring	do ..		**Langdale**............	do ..	do
astleton	**Roxburgh**	**Sunny Corner.**	**Lennox**	**Bathurst**	**Ophir Gold-field.**
oolamigal (b)..........	do	do	**Lewis**	do	do
ullen Bullen	do	do	**Mulgunnia**	**Georgiana**	**Mulgunnia Gold-field.**
skdale	do	**Clear Creek and Kirkconnell Goldfield.**	**Oberon**............	**Westmoreland**..	**Oberon Gold-field.**
			Tuena	**Georgiana**	**Abercrombie Gold-field.**
alnash	do	**Sunny Corner.**	**Worcester**	**Bathurst**	**Ophir Gold-field.**
illindich	**Georgiana**	**Junction Point, Tuena Creek, and Markdale Gold-fields.**	**Do**	do	do
				(Survey Office litho. adopted.)	

CLARENCE AND RICHMOND MINING DISTRICT.

Parish, or part of.	County.	Locality.
ullama	**Gresham**	**Boyd or Little River Gold-field. (Survey Office litho. adopted.)**

HUNTER AND MACLEAY MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
indera	**Gloucester**	**Barrington Gold-field.**	**Craven**	**Gloucester**	**Barrington Gold-field.**

LACHLAN MINING DISTRICT.

ndawarrah	**Bland**	**Temora Gold-field.**	**Parkes**	**Ashburnham** ..	**Billabong Gold-field.**
rrajong	**Ashburnham** ..	**Billabong Gold-field.**	**Young**	**Monteagle**	**Burrangong Gold-field.**

MUDGEE MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Gulgong (a)	Phillip	Gulgong Gold-field.	Hargraves	Wellington	Wellington Gold-field.
Guntawang (b)	do	do	Wyaldra	Phillip	Gulgong Gold-field.

NEW ENGLAND MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Arvid	Gough	Vegetable Creek.	Land's End (o)	Gough	Emmaville Gold-field.
Annandale	Clive	do	Muir (p)	do	do
Bundar (a)	Gough	do	Marylands (q)	Buller	Wilson's Downfall.
Bookookoorara (b)	Buller	Wilson's Downfall.	Marsh (r)	do	do
Bates (c)	Clive		Paradise North (s)	Gough	Emmaville Gold-field.
Blain (d)	do		Purvis (u)	Clive	
Bowman (e)	do		Ruby (v)	Buller	Wilson's Downfall.
Binghi (f)	do		Rockvale (w)	Clive	Emmaville Gold-field.
Boorook	Buller	Boorook Gold-field.	Rockglen (x)	do	do
Boonoo Boonoo (g)	do	do	Strathbogie	do	do
Corry (h)	do	Wilson's Downfall.	Strathbogie North (y)	do	do
Cullendore (i)	do	do	Scone	do	do
Cranbrook (j)	Clive	Emmaville Gold field.	Strachan	do	do
Callanyn	Buller	Red Rock.	Silent Grove (a^{1})	do	do
Dumaresq (k)	Gough	Vegetable Creek.	Tent Hill	Gough	do
Fraser (l)	do	Emmaville Gold-field.	Undercliff (b^{1})	Buller	Wilson's Downfall.
Flagstone	do	do	Wellington Vale	Gough	Emmaville Gold-field.
Highland Home	do	do	Wellington North (c^{1})	do	do
Hamilton (m)	do	do	Wylie (d^{1})	Buller	Wilson's Downfall.
Haystack (n)	do	Vegetable Creek.	West Fairfield	Drake	

PEEL AND URALLA MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Aston	Hardinge	Cope's Creek.	Hall	Darling	Giant's Den.
Bangheet (a)	Murchison	Bingera Diamond-field.	Hall (k)	Murchison	Bingera Gold-field.
Bingera (b)	do	do	Mayo	Hardinge	Cope's Creek.
Boyd (c)	Gough		Mitchell (l)	Gough	
Bloxsome (d)	do		Macintyre (m)	Murchison	Bingera Gold-field.
Bald Nob (e)	do		Metz	Sandon	Hillgrove.
Clive	do	Cope's Creek	Nundle	Parry	Peel River Gold-field.
Clare	Hardinge	do	Swinton	Hardinge	Cope's Creek
Cope's Creek	do	do	Severn (n)	Gough	
Coventry	Clarke		Scott (o)	do	
Cooney	Sandon	Hillgrove.	Sara (p)	Gresham	Mitchell River.
Darby	Hardinge	Cope's Creek.	Scone and Strathbogie	(See New England Mining District.)	
Dungowan (f)	Parry	Peel River Gold field.			
Dinoga (g)	Murchison	Bingera Gold-field			
Derra Derra (h)	do	do Diamond-field.	Tienga	Hardinge	Cope's Creek.
Gouron (i)	do	do do	Worra (q)	Gresham	Mitchell River.
Herbert	Gough	Cope's Creek.	Wood's Reef	Darling	Ironbark Gold-field.
Hanning	Inglis		Wellington Vale	(See New England Mining District.)	
Hall (j)	Clarke	Mitchell River.			

SOUTHERN MINING DISTRICT.

Parish, or part of.	County.	Locality.
Nerrimunga	Argyle	Nerrimunga Gold field.

TAMBAROORA AND TURON MINING DISTRICT.

Parish, or part of.	County.	Locality.	Parish, or part of.	County.	Locality.
Carroll (a)	Wellington	Hill End and Tambaroora.	Cummings (b)	Wellington	Hill End and Tambaroora
Tambaroora	do	do do			

TUMUT AND ADELONG MINING DISTRICT.

Adelong (a)	Wynyard	Adelong Gold-field.	Ellerslie (e)	Wynyard	Adelong Gold-field.
Bulloongong (b)	Murray	Captain's Flat.	Euadera (f)	do	do
Ballallaba (c)	do	do	Gadara (g)	do	do
Calafat (d)	Wynyard	Adelong Gold field.	Wondalga (h)	do	do

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL. II, PART IV.

1892.

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1892.

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GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY.

(1.) MAPS.

Map showing Mineral Areas of New South Wales. Scale, 8 miles to 1 inch.
 Do do do Scale, 50 miles to 1 inch.
Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
 Do do do do Scale, 22 miles to 1 inch.
Geological Map of the Districts of Hartley, Bowenfels, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.
Geological Map of Hill End and Tambaroora, by E. F. Pittman, Geological Surveyor.
Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 58 chains to 1 inch.
Index Map of the Vegetable Creek Tin-fields, by T. W. E. David, B.A., F.G.S. Scale, 80 chains to 1 inch.
Geological Map of the Forest Reefs District, by H. Y. L. Brown, Geological Surveyor.
Map of the Silver-mining Country, Barrier Ranges, by C. S. Wilkinson, L.S., F.G.S.
Vertical Sections of New South Wales Upper Coal Measures, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Diagrams showing the Thickness, Character, and Portion mined out of Coal-seams in the Coal Measures of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Plans showing the Outcrop, Thickness, and Dip of the Coal-seams in the Northern, Southern, and Western Coal-mining Districts of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Geological Sketch Map showing boundary of the Cretaceo-Tertiary Formation in the County of Cowper, by William Anderson, Geological Surveyor, 1889.
Geological Sketch Map of Tertiary Deep Lead, Tumberumba, by William Anderson, 1890.

(2.) PUBLICATIONS.

The Mining Act of 1884, with Regulations.
Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.
MINERAL PRODUCTS OF NEW SOUTH WALES, 1882, containing:—
 1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
 2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
 3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
 4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.
MINERAL PRODUCTS OF NEW SOUTH WALES, 2nd Edition, 1886, containing:—
 1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
 2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
 3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.
MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES:—
 Geology.
 1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.
 Palæontology.
 1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales, and Australian Museum, Sydney. (4to. Sydney, 1888.)
 2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)
 3. Geological and Palæontological Relations of the Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in Eastern Australia and Tasmania, by Ottokar Feistmantel, M.D. (4to. Sydney, 1890.)
 4. The *Fossil* Fishes of the Hawkesbury Series at Gosford, by A. S. Woodward, &c. (4to. Sydney, 1890.)
 5. A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales, Part 1, Cœlenterata; by R. Etheridge, Junr. (4to. Sydney, 1891.)
 7. The Mesozoic and Tertiary Insects of New South Wales, by R. Etheridge, Junr., &c., and A. Sidney Olliff, &c. (4to. Sydney, 1890.)
 8. Contributions to a Catalogue of Works, Reports, and Papers on the Anthropology, Ethnology, and Geological History of the Australian Aborigines, Part 1; by R. Etheridge, Junr. (4to. Sydney, 1890.)
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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. II.] 1892. [Part 4.

XX.—Notes on Experiments with the Munktell Chlorination Process at Bethanga, Victoria: by E. F. PITTMAN, Assoc. Royal School of Mines, L.S., Chief Mining Surveyor.

THE Bethanga ore deposits are very extensive, and consist of solid fissure lodes of iron, arsenical and copper pyrites, zinc-blende, and some magnetic pyrites, but with comparatively little quartz or other gangue. These mixed sulphides contain from 1 oz. to 2¼ oz. of gold, ⅓ oz. to 2¾ oz. of silver, and from 1 to 2½ per cent. of copper.

A very large amount of money has been spent by Mr. John Wallace, the owner of these mines, in efforts to find a satisfactory and economical method of extracting the gold, and, considering the large supplies of ore which can be obtained from the lodes, and the fact to be deduced therefrom, viz., that a process which would yield only a small profit per ton, would give enormous results per annum, by the use of an extensive plant, it is somewhat surprising that he has been hitherto unsuccessful. The process lately introduced by the Metals Extraction Company was fully inspected by me at the experimental works erected at Bethanga under the supervision of Mr. G. Dury, and Dr. C Mattei, Metallurgical Engineers, who came to the Colony for the purpose of treating fifty tons of the ore at the mine.

The process is essentially a chlorination process, and consists of (1) calcining the ore in heaps in the open air; (2) crushing in a rock-breaker; (3) pulverising in the dry state; (4) roasting with or without salt; (5) leaching in closed vats with hot water, collection of the water containing the copper in solution, and precipitation of the copper by means of scrap-iron; (6) treatment of the ore in the same vats with dilute sulphuric acid to remove the suboxides of iron, etc.; (7) treatment in the vats with chlorine under pressure, and collection of the liquor containing the gold in solution; (8) precipitation of the gold with sulphate of iron; (9) collection of the precipitated gold, smelting with litharge, and cupelling.

The ore as it comes out of the mine is stacked in heaps over wood, and the latter ignited. The heaps are allowed to remain until combustion of the sulphur and arsenic ceases. The ore is then crushed to small lumps in a rock-breaker from which it passes to a dry crusher, with gratings containing about one hundred and forty-four holes per square inch. The pulveriser at present in use is not altogether satisfactory, and it is proposed to use globe mills for the purpose. The pulverised ore is then roasted in a reverberatory furnace with an inclined hearth. The furnace in use is forty-four feet long and four and a half feet wide, and will roast about three tons per twenty-four hours. Two quantities, with and without salt respectively, were roasted in this furnace during my visit, and the results appeared to be equally satisfactory.

There is no doubt that in view of the experiments made by Professor S. B. Christy, in America, the use of salt in roasting auriferous ores is objectionable by reason of the volatility of the chloride of gold formed. In a paper read in May, 1887, before the American Institute of Mining Engineers, Professor Christy shows that in roasting with salt a loss of 30 per cent of the total amount of gold can easily result, and although the actual loss of gold in the nineteen tons roasted in my presence only amounted to 1·15 per cent., I have no hesitation in saying that the use of salt is too risky to be recommended.

The temperature, when roasting with salt, is kept low, the sulphur just burning, and the charge meets a slightly increased heat at the finish as it approaches the bridge of the furnace. The roasting is known to be finished when a sample of the ore is found to contain no more sulphides of copper or iron. The test for the former is made by boiling some of the samples in dilute acid, washing and decanting several times with hot water, then dissolving the residue in nitric acid, and adding ammonia, when the absence of blue colouration is proof that all the sulphide of copper has been decomposed by the roasting. Sulphide of iron is decomposed sooner than sulphide of copper, and is therefore not likely to be present if the latter be absent. It may, however, be tested for by heating a sample of the roasted ore with dilute acid in a test tube and holding over the latter a piece of filter-paper saturated with a solution of acetate of lead. A blackening of the paper denotes that the roasting has not been carried far enough.

The roasted ore while still somewhat hot is conveyed by trucks to the works, and is transferred by shoots to the vats. The vats at present in use at Bethanga, are made of wood and lined with lead. They are circular in section, and are slightly wider at the bottom than at the top. They are strongly made and are strapped with iron. The covers are of cast-iron, and are screwed down upon a ring of indiarubber to render them airtight. A false bottom is placed in each vat to prevent clogging, and insure regular percolation, through the ore, of the liquids which enter the bottom of the vat through a pipe. Pebbles, covered by a perforated sheet or disc of lead, were used as a temporary substitute for a false bottom at Bethanga. Just above the false bottom is the man-hole, through which the tailings are discharged after the process is finished. The man-hole is closed by a lead-lined iron door, which is fastened airtight by a screw. A second or exit pipe leaves the vat near the top, and through this the liquids escape after the leaching. The end of this pipe, inside the vat, is furnished with a rose formed of fibre matting or asbestos cloth, to prevent any of the finely-powdered ore from being carried out of the vat. A small branch tube leading from the exit pipe enables a sample of the liquids coming from any vat to be drawn off and tested at any time Both the entry and the exit pipes can be stopped or opened by means of clips or stopcocks. It is probable that in the event of large works being established, the vats will be made of iron (lined with lead), or of earthernware, and of three tons capacity each. Those at present in use hold about half a ton each, and there are sixteen of them arranged in a circle. They are numbered and can be connected in numerical or any other order by means of hose pipes.

Elevated about ten feet above these vats is a platform upon which stands a vat of hot water (heated by means of steam), a vat for holding dilute sulphuric acid, and a vat for solution of bleaching powder (chloride of lime). These vats are of two hundred and fifty gallons capacity, but in the case of a large plant they would be correspondingly larger. The elevation of the platform upon which these vats stand, enables their contents to enter the chlorination vats under the pressure of about half an atmosphere.

The chloride of lime, or bleaching powder, is placed along with some pebbles in a perforated barrel, which revolves when partly immersed in the water in the vat. The solution of bleaching powder thus made leaves the vat by a pipe which meets another pipe from the sulphuric acid vat. The two liquids (acid and chloride of lime) when being used are only allowed to mix just as they enter the chlorination vats.

Vats, numbered 1 to 4 are first connected, and hot water is allowed to enter No. 1 from the bottom while the ore is being charged through the top.

The cover is then screwed down, and the same process is gone through with Nos. 2, 3 and 4. The exit pipe from No. 4 vat is now connected with a copper precipitating vat and hot water is allowed to flow through the four vats for a period of about nine hours or until the washings contain only traces of copper. The chloride and sulphate of copper formed in the ore during roasting are thus dissolved and removed, and the copper is then precipitated from this solution (heated to 150° Fah. by means of a steam pipe) by scrap-iron, while the sulphate of iron resulting is used subsequently as a precipitant for the gold.

The hot water pipe is now removed from No. 1 vat to No. 5, and Nos. 5 to 8 are subjected to leaching with hot water while a pipe containing hot dilute sulphuric acid is attached to the inlet of No. 1 vat, and Nos. 1 to 4 are leached with acid for about nine hours. The strength of the acid varies according to the quantity of copper in the ore. With the Bethanga ore about twenty five litres of strong acid (specific gravity 1·75) are used with two hundred and fifty gallons of water. Vats Nos. 1 to 4 are now again treated with hot and finally with cold water until the washings give no reactions for suboxides with permanganate of potash.

The above processes are, in the same order, being alternately applied to each series of four vats in the circle. Only the first washings are allowed to flow into the copper precipitating vat, the subsequent washings being allowed to run to waste. When the first four vats have been completely washed the connections are opened and the vats allowed to drain. They are then again connected, and to the inlet pipe at the bottom of No. 1 vat is attached the pipe conveying the mixture of sulphuric acid and chloride of lime solution. The outlet pipe from No. 4 conveys the resulting solution of chloride of gold into a five hundred gallon lead lined tank, where the gold is subsequently precipitated.

The chlorination lasts about three days. As soon as a sample of the liquid, taken from the outlet test pipe of No. 1 vat, shows no reaction for gold with protochloride of tin and hydrochloric acid, the chlorine solution pipe is detached from the inlet of No. 1 and attached to No. 2, while No. 5 vat is connected with No. 4, and the solution of chloride of gold is then drawn from the outlet pipe of No. 5. The contents of No. 1 vat are then leached with water to remove the chlorine. This vat is then uncovered and the tailings are sluiced out of the manhole by means of a water-hose, and are run down shoots to the waste heap. As soon as each vat is emptied it is refilled with fresh ore.

By having the chlorinating vats arranged in a circular system the above described processes can be continuously carried out, and successive vats utilised for the various stages of the process.

Silver is not present in the Bethanga ore in sufficient quantity to render its extraction profitable.

The solution of gold from the chlorinating process is collected in five hundred gallon vats (lead lined), and is there heated to a temperature of 150° Fah. by means of steam. About twelve buckets of sulphate of iron solution from the copper-precipitating vats are then poured in, and the vats allowed to stand for some hours. The permanganate of potash test is used to ascertain when a sufficiency of sulphate of iron has been added. When the precipitated gold has thoroughly subsided the supernatant liquor is drawn off by a syphon, the gold is collected, heated with sulphuric acid (to dissolve the bulky white precipitate of basic sulphate of iron with which it is mixed), thrown on a filter, dried, smelted with litharge, soda, and borax, and the resulting lead is cupelled.

About five and one third tons (11,98¼ lb.) of ore were treated by the wet process in my presence. This required 96½ lb. of strong sulphuric acid to make the acid solution for leaching, and the chlorinating consumed 63½ lb. of strong acid, and 71 lb. of chloride of lime. This ore, before roasting with salt, contained by assay 1 oz. 14 dwt. 7 gr. of gold, 1 oz. 3 dwt. 9 gr. of silver per ton, and 0·82 per cent. of copper.* After roasting, and when put into the vats, it contained by assay 1 oz. 12 dwt. 16 gr. of gold, and 1 oz. 2 dwt. 20 gr. of silver per ton. It also contained 2·65 per cent. of sulphur (of which 2·44 was present in the state of sulphates, the balance 0·21 consisting of sulphides) and 1·21 per cent. of arsenic.

The contents of one vat after chlorination were dried and weighed, and were found to have lost 10 per cent. of their original weight during the wet process.

These tailings yielded by assay 7 dwt. 8 gr. of gold, and 1 oz. 2 dwt. 2 gr. of silver per ton, and 0·17 per cent. of copper. 20·2 per cent. of the total amount of the gold contained in the ore before chlorination were, therefore, left in the tailings. When the gold had been precipitated, dried, and smelted with litharge, it was found that the resulting alloy contained a large percentage of arsenic, and owing to an unfortunate accident with the crucible while remelting the impure lead with nitre, a considerable quantity of the gold was lost in the furnace, and I was, therefore, unable to compare the weight of gold actually extracted with the amount left in the tailings. In practice this method of precipitating with sulphate of iron, smelting with lead and cupelling, will no doubt give place to the much simpler process of precipitating the gold directly from the chlorine solution by charcoal and then burning the latter in pans. It is impossible to free the ore entirely from arsenic, even with the most careful roasting, and a small fraction of an unit per cent. in the ore will be sure to give a considerable amount of trouble in cupelling where the sulphate of iron method of precipitation is used as described above, while in the separation of the gold by charcoal filters no inconvenience would be experienced from the arsenic.

The amount of gold left in the tailings (7 dwt. 8 gr. per ton, or 20·2 per cent. of the total gold) is unquestionably too high. There is very little doubt that it is due in great part to the impure chloride of lime used. A sample of this substance, on being analysed by Mr. Dury, was found to contain only 14 per cent. of feebly combined chlorine, whereas it should contain over 30 per cent. The amount of sulphuric acid to be used with the chloride of lime in the process is determined by calculation, and is intended to be just sufficient to release the feebly combined chlorine. It is probable, therefore, that as the bleaching powder contained so much less than the normal quantity of chlorine, the acid used was correspondingly in excess of the necessary quantity, with the result that sulphate of iron was formed in the vats, and the solution of some of the gold thereby prevented. I do not think, therefore, that the process can be fairly judged by the amount of gold left in the tailings in this instance. With better chemicals I should expect the results to be very much improved with a corresponding reduction in the cost.

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* Most of the assays quoted in this paper were made by Mr. J. C. H. Mingaye, F.C.S., Analyst to this Department.

The following is, I think, a liberal estimate of the cost of treating the ore :—

	£	s.	d.	
Calcining in heaps	0	2	0	per ton of ore*
Reduction in rock-breaker	0	1	0	,,
Pulverising	0	2	0	,,
Roasting	0	11	3	,,
Cost of chemicals at present price	0	12	0	,,
Labour for chemical process	0	2	0	,,
Laboratory reagents, steam for heating vats, smelting gold, &c.	0	1	6	,,
Depreciation of plant (say)	0	3	0	,,
	£1	14	9	,,
Add cost of raising the ore	1	5	0	,,
Transport of ore to works	0	3	0	,,
	£3	2	9	,,

Properly conducted the process should extract at least 90 per cent. of the gold, and assuming that the ore contains an average of 1 oz. 5 dwt. per ton, this would be worth (say) £4 10s., so that there should be a profit of at least £1 7s. 3d. per ton. The value of the copper extracted must also be added to this.

The item "cost of chemicals, 12s." is based on the present prices of sulphuric acid, chloride of lime, and salt delivered at Bethanga, which are as follow, viz. :—

Sulphuric acid ....£20 per ton. + £3 18s. + 10s. carriage = £24 8s. per ton.
Chloride of lime ......£19 ,, + 5s. + 10s. ,, = £19 15s. ,,
Salt .... £5 ,, + 5s. + 10s. ,, = £5 15s. ,,

By making large yearly contracts, however, these prices could, I understand, be reduced nearly 25 per cent.

The roasting could also, probably, be more economically performed if a mechanical furnace were employed, such, for instance, as that designed by Mr. Merton, and used at the Clyde Smelting Works. This furnace appears to be both economical and efficient, and with it there is a very small amount of loss from dust.

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[*] Raw ore—as mined.

The chief merits of the process are (1) the fact that practically an unlimited number of vats can be worked continuously on the circular principle, the various stages of the process being carried on simultaneously; (2) there is no waste of chlorine, and consequently no unhealthy effect upon the workmen, the reason of this being that the chlorine is forced through a series of vats and has practically no means of escape; (3) the progress of the process can be readily tested at each stage, so that the foreman can always know the exact time at which the next step should be taken.

The cost of the process may appear high when compared with the economy claimed for some of the barrel chlorination processes, or the M'Arthur-Forrest Process, but the presence of copper in the Bethanga ore would be a difficulty in the way of the former, and the latter has not yet been satisfactorily demonstrated in these Colonies, so far as I know.

It appears to me that the process introduced by the Metals Extraction Company is well adapted for the treatment of the Bethanga ore, but there are few mines in New South Wales where similar conditions obtain in regard to the quality and quantity of the ore, and the occurrence of a good supply of pure water which is requisite for the process.

XXI.—On the General Geology of the South Coast, with Petrological Notes on the Intrusive Granites and their Associated Rocks around Moruya, Mount Dromedary, and Cobargo: by WILLIAM ANDERSON, Geological Surveyor.

[Plates VIII–X.]

I.—General Geology.

THE country immediately bordering the sea coast in the Southern District consists of comparatively small, isolated outcrops of granite, surrounded, and separated from each other, by a series of Palæozoic sedimentary rocks, which have a general northerly strike, except in close proximity to the granitic areas where the intrusions of the latter have produced local variations in the dip of the beds. The higher portions of the main coastal range consist of granite, which in the latitude of Bega extends as a continuous outcrop almost to the coast.

The sedimentary rocks on the coastal side of the main range, among which the granitic intrusions have taken place, consist of thin bedded argillaceous slates, with sandstones and, in a few localities, lenticular beds of limestone of no great thickness or extent. In many places they contain auriferous reefs, a few of which have returned fairly good prospects. In various localities, their denudation has shed large quantities of alluvial gold. At Nerrigundah almost the entire alluvial deposits filling the lower parts of the valleys have been turned over, and have yielded tons of gold. So far as has yet been discovered, these strata are almost entirely destitute of organic remains. The only locality in which fossils have been detected is in the limestone at Bendithera, about forty miles west of Moruya. During a recent visit to this locality I was fortunate enough to discover in the limestone referred to a thin band which is very rich in individual specimens of one genus of coral. My colleague, Mr. R. Etheridge, Junr., Palæontologist, who has examined them, informs me that they belong to the genus *Favosites*, and are probably Upper Silurian. Because of the great scarcity of fossils from this district, it is uncertain as yet to what age the strata belong, nor is there any satisfactory data to fix their stratigraphical relations to the Palæozoic rocks of the Monaro tableland on the western side of the main range. All that can be said concerning them is that they are probably of Upper Silurian age.

In various parts of the district outliers of nearly horizontally bedded Devonian conglomerates, sandstones, and shales occur, resting unconformably on the Silurian rocks, and in rare instances overlying the granites, which, however, have not intruded them. They generally form a capping to approximately north and south ridges, which occur among the higher portions of the coastal range, where they are present at intervals along a narrow belt of country stretching from Wyanbene, about forty miles west of Moruya, through Nerrigundah or The Gulph, the Black Range near Bega and Wolumba, to near Eden. In many parts of the district these denuded outliers, which often extend for miles in one direction, but are always narrow, have been mistaken by experienced miners for a cemented wash representing the bed of an old river-course, and consequently a considerable amount of useless prospecting work has been done in their vicinity, but of course with no result other than traces, or colours of gold. The presence of gold in these Devonian conglomerates would, however, show that gold-bearing reefs probably existed in the Pre-Devonian rocks from whose denudation the Devonian conglomerates were formed. The presence of marine fossils in similar horizontally bedded Devonian outliers occurring between Cobar and Wilcannia would serve to indicate that probably the Devonian rocks in this district are also of marine origin, they being hardly distinguishable petrologically and in their mode of occurrence from those on the Darling. In a north-westerly direction from this part of the coast isolated outliers of this formation are met with right up to the Queensland and South Australian borders, giving evidence of the enormous area in this Colony over which the Devonian formation was at one time developed.

The newer deposits which locally cover the Palæozoic sedimentary and intrusive rocks consist of Tertiary, Pleistocene, and Recent Alluvial accumulations. These are for the most part of fresh water or lacustrine origin, but stretching from the

Wagonga River northwards at least past Mogo, north of Moruya, occurs an alluvial deposit averaging over a mile in width and of considerable thickness, which may possibly be marine. Judging from its height above sea level, and its relation to the newer alluvial deposits, it is certainly in its origin anterior to the Pleistocene alluvials in the valleys, and may possibly be of Tertiary age. It rests locally both upon the granite and the slates, and consists chiefly of siliceous pebbles of all sizes, cemented in places and carrying traces of gold. It never occurs further inland than a few miles from the present coast line, and it is not now continuous, having been denuded locally during the excavation of the present valleys.

The Pleistocene and Recent Deposits, forming extensive flats in the valleys and on the shores of the lakes, consist chiefly of the detritus carried down by the creeks.

Besides the Post-Tertiary deposits formed by geological agents, somewhat extensive accumulations occur which have been brought together by the agency of man, and therefore date within the human period. These are the shell-heaps or Kitchen-middens which are to be found on the shore-lines of almost every inlet, lake, and river estuary along this part of the coast. They have been described in a previous Paper.*

The physical features of this coast are of the usual littoral type. The immediate coast-line is mostly formed of slate rocks, which at intervals have been worn into cliffs of considerable height, in which many caves, few of them of any extent, have been hollowed out by the action of the waves. Those portions of the coast-line which consist of granite are generally low-lying, and form long stretches of sandy beach dotted here and there with large boulders of granite. The coast in the neighbourhood of Tathra consists of an intrusive prophyry. The whole coast is indented by large numbers of extensive and irregularly formed salt water lakes, which are generally closed by sand banks except during periods when the rivers which enter their inland ends are in flood. These lakes, like Sydney Harbour and Botany Bay, were probably originally land valleys which have since been depressed below sea level. The whole coastal area is of a slightly undulating character, and the only elevation of any great height is Mount Dromedary.

Further inland towards the Monaro Tableland the general level of the country rises rapidly and becomes very mountainous and rugged, forming the main coastal range.

II.—*The Granites.*

The three areas occupied by granite on this part of the coast occur around the following centres:—Moruya, Mount Dromedary, and Cobargo. In general characters the rocks are much alike, their main masses being hornblendic and micaceous granites, containing light grey coloured felspars. Associated with the Mount

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* Records Geol. Survey New South Wales, II., Pt. II., p. 52.

Dromedary granite, however, two small areas of granite occur at the Little Dromedary which are widely different from the typical rock composing the mountain proper. The one is largely porphyritic by flesh coloured felspar, and the other is a rare form of granite containing little quartz, but characterised by the abundant presence of augite as an essential constituent. This augitic rock has no doubt some connection with the augite-felspar-mica rock referred to hereafter as occurring on the coast, and on the west side of the mountain.

(*a*) MORUYA GRANITE.—The Moruya granite has a somewhat circular outcrop about eight miles in diameter. The town of Moruya is situated near its centre. Eastward towards the mouth of the river it extends to within a mile of the sea opening, while to the westward it junctions with the slate rocks within four miles of the town. On the left bank of the river below the town it has been quarried for building and ornamental purposes. It is of a greyish colour, takes a high polish, and possesses a uniformly moderate sized crystallisation. In numerous places it has been intruded by quartz-porphyry dykes. Its utility for decorative building purposes is somewhat marred by the presence of dark coloured patches, which are occasionally of considerable extent and occur in great numbers throughout the rock, in fact the faces of the quarries are quite spotted over with them. In many cases they are undoubtedly segregations of mica and hornblende, perhaps formed from the residual magma after the general mass had crystallised. In other cases there is every reason to believe that they have been fragments of foreign rocks caught up by the intrusive mass during its passage through the strata which it has intruded. The weathered surfaces of these latter have the appearance of boulders in a conglomerate or agglomerate, some of them being quite angular. One such mass consisted entirely of crystalline quartz, which had not been crystallised in a cavity as a secondary mineral, but whose crystallisation had evidently been induced by the heated fluid magma in which it had been caught up. Many of these dark patches present a distinct lamination which may represent the original sedimentation lines or a secondary schistose lamination produced by the pressure of the enclosing granitic rock-mass.

I quote here an analysis of this granite given by Prof. A. Liversidge in his Minerals of New South Wales.*

Sp. Gr. 2·678 at 21° C.

Hygroscopic moisture at 100° C.	·168
Silica	67·557
Alumina	16·391
Iron sesquioxide	1·246
Iron protoxide	1·858
Manganese protoxide	·794
Lime	5·075
Magnesia	1·484
Potash	1·770
Soda	3·540
	99·883

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* P. 224.

(1.) *Micaceous or Hornblendic Granite.*—Microscopically it is a grey granite and is never largely porphyritic. As a rule it is of moderate texture, but it differs locally, some portions of the outcrops being finely crystalline. The mica and hornblende are generally evenly distributed through the rock, but in some places the chief minerals are quartz and felspar, the former predominating. This usually occurs in the immediate neighbourhood of the finely crystalline segregations of mica and hornblende.

Microscopical Characters.—The typical rock is represented by *Slide No.* 293 which shows a moderate crystallisation. It consists of triclinic felspar, quartz, mica, and hornblende with apatite microliths. The triclinic felspars are slightly porphyritic, and are generally clouded. Usually the opaque material is confined to the centre of the felspar individual, this kernel being surrounded by clear felspar, which is probably of secondary origin. Many of the felspars contain a central twinned crystal of triclinic felspar, surrounded by a peripheral felspathic zone, each of which polarises independently of the other. The central crystal has its angles usually rounded as if it had undergone a certain amount of corrosion, and from the way in which the edges of the peripheral zone are indented by the surrounding minerals, it is evident that the latter zone is of secondary growth. There are other evidences, in most of the felspars, of secondary growth. The dividing lines between the primary and secondarily formed felspar are marked off by rows of minute rounded quartz grains, which have certainly been originally individuals of primarily crystallised quartz, subsequently surrounded by the secondary growth. This feature is quite characteristic of this section (Pl. X, Fig. 1). The quartz is very irregular in outline, is usually in minute grains, and speaking generally, is more abundant than is the case in the granite of Mount Dromedary. The mica is in small light coloured plates having frayed edges. The hornblende is green, contains many inclusions, and shows the characteristic cleavages. The two latter minerals are about equally abundant. Apatite microliths are very minute and do not occur very frequently.

Slide No. 294 is a finer grained variety, the constituent minerals being the same as in the last case, but the individuals are much smaller, and the microliths of apatite are far more abundant.

Slide No. 292 is a section of the granite in the immediate neighbourhood of one of the micaceous segregations and chiefly consists of quartz with very little triclinic felspar. The large individuals of both mica and hornblende exhibit a twisting of the laminæ as if produced by pressure after their crystallisation. In some cases they seem to have been broken, and the ends appear as if forced into the neighbouring individuals. Little or no apatite is present in this section.

(2.) *Quartz and Felspar Porphyry.*—*Slide No.* 299 is a section of one of the porphyry dykes which have intruded the Moruya granite. The porphyritic minerals are quartz and felspar, but they are barely macroscopic. They are much corroded and cracked, and in a few instances the hornblende might be said to be porphyritic. The base consists of lath-shaped felspars and quartz with fine hornblende microliths. This rock bears a close resemblance to the typical Moruya granite in its general constitution, only differing in its more minutely crystalline texture.

(3.) *Foreign inclusion in Moruya Granite.—Slide No.* 300 is taken from a foreign fragment included in the Moruya granite. It is micro-crystalline in texture, and consists of felspar, augite, magnetite, hornblende, and quartz, with a little apatite. The rock has undergone considerable decomposition. There are a few porphyritic crystals of felspar present, which polarise with great brilliancy, but the general mass is fine grained. The hornblende crystals are remarkably well defined. The quartz is certainly of secondary origin, and I am rather inclined to think that the hornblende is also. Under these circumstances the rock would either be a dolerite or an andesite, probably the latter. It is certainly an example of a fragment of foreign rock caught up by the granite. In this fact lies its chief interest, and it lends thereby additional proof of the intrusive character of the granite.

(*b*) MOUNT DROMEDARY.—Mount Dromedary is an isolated mountain 2,706 feet in height, about six miles from the coast, rising from the undulating littoral area which flanks the main coastal range and lies between the latter and the sea. Its chief mass consists of an intrusive granite. The slates among which the intrusion has taken place do not now occur higher than the base of the mountain. Its surfaces, particularly near the summit, are very rugged and covered with dense vegetation; in fact, so difficult of access are some of the gullies upon its sides that prospectors have been debarred from thoroughly prospecting them even for alluvial gold. On the eastern flank of the mountain reefs have been and are now to a certain extent being worked. They consist of comparatively thin pyrites quartz veins which contain payable gold in such portions of them where the pyrites has undergone a thorough decomposition. These reefs occur in the centre of the granitic mass, and so far as proved are permanent to a depth of over two hundred feet from the present surface. In their neighbourhood many of the joints in the decomposed granite have been found to be rich enough in secondarily deposited gold to repay the work of tunnelling and washing even where neither reef-quartz nor pyrites were present. It is just possible that the hornblendic granite, although not gold-bearing in the sense that it contains free gold as a primary mineral, may have to a large extent supplied, from the decomposition of its contained hornblende the free gold now found in its decomposed portions and joints. This decomposition would never by itself produce payable gold in the general mass of the granite, nor in the alluvial deposits formed by its superficial disintegration, unless free gold was present originally in the rock; but as previously stated, when it occurs in the neighbourhood of gold-bearing pyrites veins as it does near the top of the mountain it must materially assist in increasing the quantity of free gold resulting from the decomposition of the pyrites in the veins. As a rule the decomposed portion holds enormous quantities of water, whose presence makes it rather difficult to work the reefs in any other way than by tunnelling.

(1.) *Hornblendic Granites* (*Macroscopic Characters*).—Locally the granite varies much in texture and colour. On the mountain itself it is light grey, generally fine grained, with a few porphyritically developed crystals present. On the eastern flank of the Little Dromedary it is more of a flesh colour, containing large porphyritic crystals of felspar. Usually the hornblende and mica are not much in evidence, but occasionally they are abundant. It also contains micaceous and hornblendic segregations and inclusions of foreign rocks, but these do not occur so frequently as they do in the Moruya granite.

Microscopic Characters.—*Slides* 237*a–b* are from the top of Mount Dromedary. The more finely crystalline portions consist of triclinic felspar, quartz, hornblende, and mica, with occasional crystals of a yellow, translucent, isotropic mineral, which is probably garnet. The felspars are usually full of inclusions, are well crystallised, and exhibit well-defined zonal growth lines. In some instances there is a distinctly cross-hatched structure which seems to indicate the presence of microcline. The hornblende, or its product of decomposition (epidote), is often intercrystallised with and appears included in the sections of felspar (Slide No. 237 *a–b*). The included dusty material is frequently arranged along the zonal growth line and sometimes penetrates the crystals from their edges at right angles to their longer axes. Minute crystals of apatite are often seen as inclusions, together with microliths of hornblende. Iron pyrites occurs plentifully, while garnet occurs rarely, usually as an intergrowth with the hornblende and generally surrounded by a dense black border. The latter mineral is as a rule much broken up into minute flakes, or small plates in which the individual crystals are discernable. It seems to have been one of the most easily decomposed minerals, its place being now taken by epidote.

Slide No. 240, from a cutting on the main road, north of Tilba Tilba Township, is similar in structure to the rock described above from the top of the mountain, with the exception that the porphyritic felspars are more largely developed and the hornblendes more decomposed.

Slide No. 240 is from Conditional Purchase 328, north-east of the Little Dromedary. The felspars in this rock are flesh coloured and largely porphyritic. The hornblendes are much decomposed, and all the minerals are more or less saturated with ferruginous material.

(2.) *Augite Granite.*—Between the porphyritic flesh coloured granite on the eastern flank of the Little Dromedary and the granitic junction with the slates at Little Lake, near the coast, a narrow belt of augite granite occurs. Its junction with or relations to the flesh coloured granite were not observed. It is a dark coloured rock with grey felspars and occasionally large porphyritic augites. Its characteristic constituent is augite which is rather a rare occurrence in a plutonic rock, as it is usually found in rocks which have crystallised on or near the surface. It is however here associated with other eruptive rocks which contain augite as an essential mineral, and which will be hereafter described as andesites and propylites. This is as far as I am aware the first occurrence of an augite granite in this colony.

Slide No. 238, from conditional purchase 19, east of Little Dromedary, consists of triclinic and orthoclase felspar, augite, hornblende and quartz with iron ores. The augite is of a light green colour and full of inclusions, and is intimately associated with the hornblende when the latter is present. In many of the sections of augite the peripheries are composed of brown hornblende which shows the characteristic cleavage of the latter and may possibly be a secondary alteration of portion of the augite. The augites have all a distinctly marked thin, black border. The felspars are rather opaque, due to kaolinisation (Pl. IX, Fig. 5.)

Slide No. 295, from the road to Little Lake, east of Little Dromedary is similar in composition to the last. Here many of the hornblendes are quite distinct from the augites, and show inclusions which are remarkably like those occurring in the undecomposed augites, numbers of which contain irregular local patches of hornblende, showing undoubtedly that most if not all the specimens of the latter mineral have resulted from the alteration of augite. Some of the hornblendes still show a kernel of recognisable augite surrounded by pale green hornblende, the alteration having evidently taken place from the periphery of the crystal inwards. Quartz is by no means plentiful in any of the sections of this rock.

Slide No. 298, from road to Little Lake, east of the Little Dromedary, shows a large porphyritic crystal of augite nearly a quarter of an inch in its longest diameter, with a deep green border, and having its inclusions arranged in an indistinctly zonal manner. The hornblende in this section is readily distinguished as it occurs in isolated crystals, and differs in colour from a dull yellow to an opaque green. Scattered through the section occur irregular patches of a light claret coloured mineral which contains included crystals of the other minerals and is indented by them. It is singly refracting and does not occur in a crystalline form but has a very irregular outline, and in some instances occurs in the interior of the felspar and augite crystals. There is I think very little doubt that the mineral is garnet. In most of the augite crystals, the individual zones polarise in different colours in a concentric manner. This rock somewhat closely resembles, except for the presence of quartz, the rock hereafter described as an augite-felspar-mica rock.

(*c.*) COBARGO GRANITE.—The granite in the neighbourhood of Cobargo extends from about two miles west of the town to Breakfast Creek on the east, a distance of about eight miles.

(1.) *Hornblendic Granite.*—Like the rock of Mount Dromedary it is a hornblendic granite, but presents a somewhat darker appearance, from the greater abundance of mica and hornblende present. It also contains more free quartz.

Slide No. 239, from the road between Cobargo and Bermagui is a section of the typical rock, and consists of triclinic felspars, quartz, hornblende, and mica. So far as I have seen there is no garnet present. The felspars are somewhat opaque, the dark material being arranged in a zonal manner and along the twinning planes. The hornblende varies in colour from pale yellow to light green, and shows the cleavage very distinctly.

(2.) *Quartz and Felspar Porphyries, Slide No.* 274, from the road between Cobargo and Bermagui, is associated with the Cobargo granite, probably in the form of an intrusive dyke. It is a quartz and felspar porphyry. Its base is chiefly composed of minute spherulites embedded among microliths of felspar and quartz. Great numbers of microscopic crystals of a green colour are scattered through the base. They are probably decomposed hornblende. The porphyritic ingredients are quartz, triclinic felspar, and hornblende all much corroded. The last named mineral is decomposed into a green serpentinous looking mineral similar to the green microscopic crystals in the base and containing in one or two instances included lath-shaped crystals of twinned felspar.

(3.) *Dolerite.—Slide No.* 284 is from the main road from Cobargo to Tilba Tilba, near Selection 180. This rock occurs as a dyke mass in the slates immediately to the north of their junction with the Cobargo granite. It is porphyritic by triclinic felspar. It has a doleritic structure and consists of augite, triclinic felspar with magnetite. It would therefore be classed as a dolerite. The felspar crystals indent the augites in a way characteristic of basaltic rocks. Free quartz occurs in the section as porphyritic masses having a somewhat circular outline which is separated from the general crystallised magma by a layer of minute radially situated crystals, which would seem to show that the quartz was of secondary origin and was formed in a cavity as an amygdule. The quartz itself is not in the form of mosaic but polarises as a single quartz plate. It is full of included bubbles, and each plate fills a single cavity.

It is possible that this doleritic dyke mass may have some connection with the small flow of Tertiary lava which occurs overlying the granite and slates between Cobargo and Bermagui, for so far as is known there are no volcanic cones in this district from which the lava could have come.

III.—Andesites.

Associated with the granites of Mount Dromedary and intruded by them, volcanic rocks occur which intrude the slates of the district. They are exposed chiefly on the coast in the neighbourhood of Tilba Tilba Lake, immediately to the east of the mountain, and consists of hornblende and augite-andesites, with their contact varieties, and an augite-felspar-mica rock, which is represented on the western side of the mountain by a small outcrop on Selection No. 375, Parish of Wandellow.

The coast section at Tilba Tilba Lake shows the intrusive character of both the granite and the augite felspar-mica rock together with a dyke of augite-andesite. Immediately to the south of the outlet of the lake the granite is seen to have intruded the andesites, while about a mile further north the intrusive junction of the augite-felspar-mica rock with the slates is beautifully seen. The cliffs forming the south head of the lake outlet are composed of hornblende and augite-andesites. At one or two points on the beach a floor of granite is exposed which can be traced up to the foot of the cliff, where it forms a decidedly intrusion junction with the andesitic rock, there being a distinct narrow felspathic zone between the two. The porphyritic granite passing up into this zone becomes more of the nature of a fine grained felspathic porphyry, tinged in places with the peculiar greenish colour from the rock which it has intruded. In many positions in this cliff section fine grained felspathic dykes of various thicknesses can be traced passing from the granite into the andesite. They are light coloured porphyries, and in close relation to many of them masses of breccia occur containing fragments of both rocks.

To the north of the lake the augite-felspar-mica rock is exposed on the shore. It is a very heavy black rock containing a good deal of mica. It is wholly crystalline and very coarse grained in texture. Near its junction with the slates, however, it becomes fine grained and compact. The junction is very well marked, and numerous fine grained dykes pass from it into the slates, which at this point dip to the eastward. These are chiefly intruded along the strike of the slates to the north. Light coloured felspathic porphyry dykes, about a chain in width, also intrude the slates in an easterly direction, and cut the dark coloured dykes as well. Inclusions of the augite-felspar-mica rock are of frequent occurrence in the felspathic dykes. There is, I think, little doubt that these felspathic dykes come from the granites of Mount Dromedary, and in their passage through the mass of the augite-felspar-mica rocks, have caught up fragments of the latter. The stratigraphical relations which the andesites bear to the augite-felspar-mica rock have not been worked out, as the country at this point is covered with sand dunes which completely conceal their junction.

Inland to the west of the lake-outlet the rock exposed on the surface is chiefly hornblende-andesite with local decomposed portions, which are propylitic.

(1.) *Hornblende-Andesite.*—This rock, whose minute structure is seen in the typical Slides Nos. 248*a* and 249*a*, from about a mile west of the mouth of Tilba Tilba Lake, consists of a fine aphanitic base composed of minute lath-shaped crystals of triclinic felspar with magnetic and iron pyrites, the iron constituents being frequently aggregated into small irregularly shaped masses. Throughout the base large porphyritic crystals of hornblende, augite, and felspar are distributed. Some portions of the base present, in transmitted light minute irregular clear patches, which under polarised light are completely isotropic. These probably consist of glass, containing a good deal of dusty material which under a high power resolves itself into microliths, seemingly of augite. The arrangement of the constituents of the base shows a distinctly fluidal structure, which is particularly apparent round the ends of the porphyritic minerals, and between two closely contiguous crystals. The base is often streaked with a light green material, (viridite) and along these lines the ferruginous constituent is generally very abundant. Scattered throughout the base many minute green patches occur which may possibly be aggregations of small hornblende crystals, but more probably a green decomposition of micro-porphyritic augite. Fragments of the base occur in indentations in many of the porphyritic minerals. Throughout the base numerous minute fragments of hornblende occur, having always a rounded form with black bordered outlines. These have at first sight all the appearance of being primary basal constituents, but on closer examination I think that they are certainly the last remnants of small porphyritic hornblendes which have barely withstood complete magmatic resorption before the base had undergone final solidification. The same may be said with regard to the occurrence of small augites in the base. In the case of the hornblendes the corrosions have in many instances gone on to such an extent that the position only of the original crystal is marked by an aggregation of magnetite grains. So far as observed there is little or no primary free quartz in the typical specimens of this rock.

In those sections representing the typical rock felspar as a porphyritic constituent is sparingly developed, and never attains the size of the other porphyritic ingredients, although in the altered and decomposed portions of the rock near the junction line of the granite, it is of very common occurrence. The chief porphyritic mineral is hornblende which occurs occasionally in fairly well formed crystals, showing the characteristic cleavage. They are however generally more or less rounded in outline, the result of corrosion. The largest forms which they assume, are elongated, of unequal thickness and irregular outline, attaining a length of one-eighth of an inch. They are always of a yellowish-green colour, having a deep black border evidently consisting of magnetite grains, except in Slide No. 248 where it is comparatively thin.

The border is deepest on those forms which are rounded and have undergone most corrosion, and is less prominent on those still presenting crystalline edges. This would seem to indicate that the black magnetite border was a secondary segregation of the iron constituents of the base, aided by that resulting from the corrosion of the peripheral portions of the hornblendes themselves, during the period between their own crystallisation and the final solidification of the base. They often exhibit a distinctly zonal structure, a well marked cleavage, and are frequently twinned. Inclusions of the base, as well as included crystals of augite (?) occur in them, while two or more crystals, commonly occur in apposition forming aggregates. These often have between them at their line of contact, a deep black band, showing that probably they have not been crystallised together but have been simply carried against one another during the flowage of the base. It would seem probable that the hornblendes are of two generations, the larger number being of primary origin, while a few have resulted from the uralitisation of augite. The corroded forms may possibly be foreign to the rock, but I think that it is more probable that they were simply the first mineral to crystallise out as porphyritic constituents, and that subsequently and during the crystallisation of the base they had undergone peripheral corrosion.

In addition to the porphyritic hornblende and felspar, and almost equally abundant with the former, a clear mineral is porphyritically developed which is usually much cracked and contains a good deal of greenish decomposition material. It presents in section a somewhat roughened surface, resembling that characteristic of olivine, but in all three slides there occur one or two small undecomposed forms having a perfectly crystalline outline and showing undoubtedly the cleavages of augite. In some cases they occur aggregated together into large irregular compound crystals, while sometimes two crystals appear in apposition so as to resemble in section geniculate twins, but this is I think accidental. Like the other porphyritic constituents they have individually undergone, to a considerable extent, magmatic resorption, which has often entirely obliterated their crystalline outlines. They frequently present a black border, which however is never so deep nor so well marked as in the case of the crystals of hornblende. Inclusions of the base and small aggregates of the magnetite occur in them. Some of them show twinning, and they have usually undergone a certain amount of decomposition. The resulting green product is sometimes merely peripheral, but generally passes through the crystal in irregular lines, and in some instances the whole substance of the crystal has been converted into this green material. Frequently there appears to be in those altered forms indications of hornblende cleavage, and it is quite evident in the decomposed specimens of this rock, described below, that the alteration which the augite has undergone has been into uralite. In this way some of the lighter coloured hornblendes, having ill defined borders, have no doubt been derived by alteration from the augites.

This rock is certainly a quartzless hornblende-andeisite, the chief porphyritic constituents being hornblende and augite, the latter mineral having been frequently converted into uralite. Both minerals have been among the earliest to crystallise out, and have been present in a crystallised form before the final consolidation of the base. There is a little glassy base, but in the typical rock there are a few porphyritic felspars and no primary free quartz. As will be shown further on, in examining sections of this rock near its junction with the intrusive granite, one of the characteristic features of the contact rock is that almost the only porphyritic constituent is felspar, the hornblende and augite being reduced to a minimum. Fig. 1 Pl. IX., represents a portion of Slide No. 249 b.

An ultimate analysis of the hornblende-andesite, made by Mr. J. C. H. Mingaye, Assayer and Analyst to the Department of Mines, is given below, and with it a few analyses of typical hornblende-andesites for comparison:—

	1	2	3	4	5
SiO_2	52·12	59·75	58·84	55·75	52·68
Al_2O_3	18·47	17·25	17·09	20·42	12·66
Fe_2O_3	3·40	7·57	....	6·14	17·34
FeO	4·77		10·61	....	....
MnO	Trace.	....	....	....	Trace.
CaO	8·71	6·00	7·03	8·33	11·45
MgO	5·11	1·30	3·90	3·79	0·93
K_2O	3·29	3·10	0·83	1·90	1·91
Na_2O	3·07	4·00	2·12	5·74	2·49
P_2O_5	·25	....	....	....	....
SO_3	Trace.	....	....	....	....
T. O.	Heavy trace.	....	....	....	....
Moisture	·46	1·00	....	....	....
	99·65	99·97	100·42	102·37	99·46

1. Analysis of hornblende-andesite from a mile west of the entrance to Tilba Tilba Lake, South Coast, by J. C. H. Mingaye.
2. Mean analysis of quartzless hornblende-andesite. Von Lasaulx.
3. Analysis of an andesite from Gunung Patna, Java. Prölss, N. Jahrb. f. Min. 1864, p. 432.
4. Analysis of an augite-andesite from the Usiu Pass, Japan, by O. Korschelt. Trans. Asiatic Society of Japan, 1880.
5. Analysis of augite-andesite from N.W. spur, Beinn Hiant, Mull, by W. Tate, Normal School of Mines. Quart. Journ. Geol. Soc., Vol. XLVI, p. 379.

(2.) *Augite-Andesite.*—This is the form which the andesitic rock assumes in the cliff section at the south head of Tilba Tilba Lake, where the granite can be seen intruding it. It differs somewhat in structure from the hornblende-andesite just described, which occurs further inland, and whose junctions with the granite have not been observed. For the latter reason it is unknown whether the last named rock is intrusive or has been a lava.

Slide No. 276 is from the southern end of the bluff forming the south end of the Tilba Tilba Lake. The base consists of triclinic felspar, magnetite, and augite, with some glass and viridite, a decomposition product from the augite or hornblende. The felspars are lath-shaped and somewhat opaque, and larger than they are in the hornblende-andesites. The chief porphyritic constituent is clear augite, having distinctly crystalline outlines and being traversed with several irregular cracks, which are filled with a yellowish green decomposition material. There are a few small porphyritic hornblendes, the major portion of which have been converted into fibrous radial epidote surrounded by a border of magnetite grains. The augites show in some cases zonal growth lines, and are often aggregated together, the spaces between the crystals being occupied by small irregular patches of the base. No porphyritic felspars are present, and the rock generally has the same structural characters as the hornblende-andesites, the only difference being that the porphyritic augites predominate over the hornblendes, and therefore it may be classed as an augite-andesite (Pl. X, Fig. 2.)

Slide No. 282 is from the northern end of the bluff forming the south head of Tilba Tilba Lake. This specimen was taken near the junction of the andesite with the granite, but not at the actual point of contact. Its base is exceedingly fine grained, consisting of minute triclinic felspars and magnetite with a good deal of green decomposition material. Its chief porphyritic constituents are triclinic felspars and clear augites, showing serpentinous decomposition along the cracks. Hornblende, if it is represented at all, is in the form of a green decomposition product. The porphyritic crystals are much corroded, and the base is quite similar to that of the last section and the hornblende-andesite. It is evident that these two forms merely represent local differences of the same rock mass.

IV. Contact Rocks.

Considerable alterations in the general structure of the andesitic rock have taken place towards its junction with the intrusive granite. These results have been produced first by the intrusion of the granite and subsequently by decomposition, and are to be observed as a passage from the typical undecomposed andesitic rock to the purely felspathic pyritous rock which form the actual contact zone between the two. The first noticeable difference is the decomposed condition of the rock, and the development in it of large quantities of zonally built and now kaolinised felspars. The porphyritic augites are almost entirely converted into uralite and the hornblendes into epidote, thus producing propylite. Considerable portions of the contact rocks are brecciated, exhibiting strong evidences of flowage. It usually appears glassy as if the greater portion of the rock in such positions had undergone remelting at the time of the granitic intrusion, and subsequently solidified as a glassy rock containing microliths and porphyritic crystals of felspar and hornblende, many of the latter, however, being the original black-bordered hornblendes of the andesite which had partially withstood the process of resorption. Enclosed in this glassy matrix occur fragments of all the various altered forms of the andesite. Compared with the typical andesite the iron in the base of the altered varieties has been considerably lessened in amount as a microscopic constituent, but has been developed as microporphyritic iron pyrites. This secondary development of iron pyrites in the rocks near the junction lines is quite a characteristic feature in the coast section to the south of Tilba Tilba Lake.

The contact rocks will be described under the following classes:—Propylitic andesites or propylites, glassy andesitic and propylitic breccias, and felspathic contact rocks.

(1.) *Propylitic Andesites or Propylites.*—The rocks which I have classed as propylites occur associated both with the hornblende-andesite to the west of Tilba Tilba Lake, and with the augite-andesite forming the bluff at the southern head of the lake. It is evidently a contact rock, and has been produced merely by alteration from the andesite by contact and subsequent decomposition.

Slides Nos. 249 and 251 are from a mile west of the mouth of Tilba Tilba Lake. They possess a base similar to that found in the andesites above described, but the iron constituent is not so plentiful, while the felspars, many of which are porphyritic, are developed in greater abundance, and in larger and more defined crystals. They are much clouded, and the whole rock has undergone great decomposition, the base being freely speckled with viridite. In a few instances, much corroded, deep black-bordered crystals of brown-coloured hornblende occur porphyritically, but as a rule they are almost entirely converted into epidote, while commonly the position which they occupied is now represented by a corroded mass of opacite, still exhibiting indistinctly the crystalline outline of hornblende. The other porphyritic constituent has been entirely converted into a green mineral which shows the pleochroism and in many cases the cleavage of hornblende. This is evidently an alteration mineral, and is no doubt uralite resulting from the alteration of augite. This is well seen in Slide No. 260 (Pl. IX, Fig. 2). Some of the uralite still shows portions of the clear unaltered augite. Iron pyrites also occurs as a microporphyritic constituent.

Slides Nos. 252, 252a, 260, 275 are taken from the bluff forming the southern head of Tilba Tilba Lake. Their base contains a great deal more magnetite and iron pyrites than was the case in the two former slides. The originally porphyritic hornblende has been almost entirely converted into epidote which also occurs scattered through the base. The augite has also undergone uralitisation. The chief peculiarity of this rock is, however, the abundance of porphyritic felspar which possess a remarkably zoned structure. Many of the crystals have a completely opaque centre, surrounded by a clear peripheral zone, while others have alternate opaque and clear concentric zones of unequal thickness. It is common to find them exhibiting fracture, in some instances with but slight displacement, and in others the fractured pieces have drifted apart and are slightly corroded. They are best seen in Slide No. 252, from which the individuals in Fig. 3, Pl. IX, are taken. Occasionally their arrangement would indicate that movements of flowage had taken place in the base after their formation. Some of the larger forms show a central nucleus of magnetite grains. This would, I think, lend support to the supposition that many of them are of secondary origin, that is to say, that they were formed in the rock as a result of the intrusion of the granite. Slide No. 275 is partially brecciated and contains a good deal of glass.

In every particular this rock presents a pathological condition of the typical andesite described above, and therefore would be classed as a propylite, its chief characteristics being the uralitisation of the augite and the secondary development of large quantities of zonally built felspars. On the coast this rock only occurs in the neighbourhood of the junction lines with the granite, and this position would explain its altered condition which has no doubt been chiefly brought about by decomposition by percolating water, together with the effects produced by the intrusion of the granite.

(2) *Glassy Andesitic and Propylitic Breccias.*—In close connection with the lines of contact between the felspathic dykes and the andesite, glassy breccias have been formed. These consist chiefly of a glassy matrix, exhibiting flowage, throughout which are scattered small porphyritic crystals of felspar and hornblende, and enclosing fragments of the different varieties of the andesitic rock. They are represented by Slides Nos. 272, 254, 255, 256, 257, 259, 261, and 262. The majority of the fragments forming the brecciated portions consist of the propylitic variety containing the porphyritic felspars. The bulk of the sections however consist of glass, the microliths and dusty material in which are arranged in lines giving the rock the appearance so common to banded rhyolites. In Slides Nos. 255 and 262 (Fig. 4, Pl. IX), this banding is distinctly visible to the naked eye. In every case porphyritic crystals of triclinic felspar, hornblende, and augite are present in the glassy base. Few of these have distinctly crystalline outlines, and in many cases it is evident from their rounded and irregular form that they have been in process of resorption when the glassy base solidified, and there is little doubt that at least the hornblende and augite are the unmelted remnants of the original andesitic rock which must in these positions have undergone almost complete melting at the time of the intrusion of the felspathic dykes, and solidified rapidly as a glassy breccia along the immediate lines of contact. These breccias occur chiefly in connection with the felspathic dykes, and it is most probable that the intrusion of the latter produced two series of phenomena, the first being the development of porphyritic felspars in the andesite for a considerable distance

from the contact, and the second a remelting of the contact andesite which resulted in the production of the glassy breccia. Such breccias have not been formed at the contact with the mass of the granite which is separated from the andesite by a purely felspathic zone. Slide No. 272 contains a good deal of secondary quartz; most of the iron is in the form of pyrites, and a few grains of porphyritic augite are present. The brecciated character of Slide No. 256 is shown on Fig. 3, Pl. A large portion of Slide No. 261 might be classed as fine grained porphyrite.

(3.) *Felspathic Contact Zone.*—The rock which occurs exposed at the base of the andesite cliffs, forming the southern head of Lake Tilba Tilba, is represented by Slide No. 253. It is a felspathic rock and closely resembles the intrusive granite, and passes, towards its junction with the andesite, into the felspathic contact zone. Under the microscope it is seen to consist of a fine grained felspathic base composed of minute felspars, mica, magnetite, and a green decomposition product. Its chief porphyritic constituents are triclinic felspar, green hornblende, which in a few instances seems to be primary, and in others bears a strong resemblance to the vertical sections of uralitised augite, mica, and iron pyrites, the latter being no doubt secondary. The felspathic constituents are opaque from kaolinisation, and the porphyritic individuals are much cracked, presenting a net work with little or no clear felspar in the meshes. Some fibrous epidote is present, probably resulting from the decomposition of hornblende. The rock would certainly come under the granitic porphyries, having the mica and hornblende as accessory minerals. In its general structure and composition it is undoubtedly connected with the granite, and from it felspathic dykes can be seen passing into the andesite.

The actual contact zone between this rock and the andesite is formed of a fine grained highly felspathic rock. In structural characters it differs somewhat in different positions. Slide No. 264 is a micro-crystalline rock (Pl. X, Fig. 5), consisting chiefly of triclinic felspar with a little hornblende, most of which has been converted into epidote. A good deal of aggregated secondary iron pyrites is present, as well as a small amount of free quartz. There is, however, hardly sufficient of the latter mineral present to class the rock as a granite. The other sections of the contact rock, comprising Slides Nos. 250, 258, and 263, are much finer grained than that last described, in fact, they may be classed as felspar porphyries. They consist of a micro-felsitic base formed chiefly of minute felspars and quartz, in which are developed porphyritic crystals of triclinic felspars, with very rarely a small hornblende crystal, which has usually, however, been converted into epidote. The base is very ferruginous, and there is a good deal of iron pyrites present. The porphyritic felspars are usually much obscured by kaolinisation.

From the general characters of the specimens just described it would seem to me that this felspathic contact zone had been formed from the granitic magma rather than from the andesitic rock, as there is no evidence of any actual admixture of the two rock masses having taken place to form a contact zone. The line of demarcation between the decomposed or propylitic andesite, and the felspathic contact zone is distinctly marked, although there is, I think, no doubt that the production of the porphyritic-zoned felspars in the propylitic rock has been due to the action of the intruding felspathic rock.

V.—Augite-Felspar-Mica Rock.

This rock is associated with the andesites on the coast at the mouth of Tilba Tilba Lake, and occurs on Portion 375, Parish of Wandellow, on the western side of the mountain where, so far as I know, the andesite is not represented. The rock exposed at the mouth of the lake is augite-andesite, and about a mile further north this rock crops out on the beach, but at no point is the actual junction between the two rocks seen, the only exposures being a few isolated weathered surfaces appearing through the sand between tide marks. The relation which this rock bears to the andesite is therefore at present unknown. That it is an intrusive rock there is no doubt, as exhibited by its contact with the slates, and the dykes which traverse them from that junction. These are well seen about a mile north of the lake outlet. They differ considerably in structure, although they contain the same minerals, and it is just possible that these may be independent intrusions, although in no case have I seen dykes of this rock intruding the andesite. In the Parish of Wandellow, to the west of the mountain, this rock crops out as a small oval patch near the junction between the slates and the granite.

At Tilba Tilba Lake the rock is a very heavy, greenish-black ultrabasic rock. Its chief characteristic microscopically is the great abundance of augite and mica, the felspar being by no means a prominent feature in it. It is granitic in texture, its chief constituents being augite, mica, iron ores, and a little felspar. The most abundant mineral is certainly the augite which rarely occurs in decided crystals. It has a greenish tint, is frequently twinned, contains a large number of inclusions, and is much cracked. Some of the inclusions are arranged in lines no doubt along the cleavages, for many of them cross each other at right angles.

The mica is next in abundance and is of two shades, a dark brown, which rarely shows the striations, and a light coloured mica in which they are always present. Many of these latter forms show a remarkable bending or twisting of the laminæ, which in some of the individual crystals are bent in two directions in their course from one end of the crystal to the other. It usually forms aggregates, and the edges are usually indented by irregular protrusions from the augite individuals.

The felspars are triclinic, and the iron ores occur as black opaque specks and aggregations chiefly in the augite and mica and between the other minerals.

Slide No. 285 is from the first outcrop north of the mouth of Tilba Tilba Lake. The chief minerals are augite, mica, and iron ores, principally iron pyrites. The felspar is triclinic and by no means abundant. Scattered through the slide are minute hexagonal sections of a clear mineral sometimes having a nucleus of iron ore and containing large quantities of inclusions having a circular outline.

Slide Nos. 265*b and* 277 are from Portion 375, near Dignam's Creek, on the west side of Mount Dromedary, and contains a greater abundance of felspar than the preceding, and shows intergrowths of mica and augite, and mica and iron pyrites. Pl. IX, Fig. 6 is a portion of this slide.

Slide No. 306 is from one mile north of Tilba Tilba Lake. It is very fine grained, and the minerals are remarkably fresh and are about equally distributed. The felspars contain large quantities of apatite microliths. Some of the augites exhibit schillerization and in many cases are intercrystallised with the mica.

Slide No. 278 is taken from a specimen procured by one of the Inspectors of Agriculture to this Department, from near Tilba Tilba Lake, the exact position being unknown. It is undoubtedly, however, referable to this rock, but differs from any of my specimens, in the fact that it is distinctly porphyritic by augite. It consists of a fine grained base of triclinic felspar, augite, mica, and iron ores, in which large porphyritic augites have been developed. Their peripheries are altered into a pale green mineral, which is possibly mica, and they are as a rule schillerized towards their centres.

Slide No. 289 is taken from the actual contact between the intrusive rock and the slates about a mile north of the outlet of Tilba Tilba Lake. It is considerably altered and is of a doleritic texture, consisting of triclinic felspar, uralitised augite, mica, and iron ores. The felspars contain apatite, and the skeleton crystals of iron ore have their meshes filled with mica. In most cases, the uralitised augite has undergone further alteration into epidote.

Slide No. 265 (*a*) from Portion 375, near Dignam's Creek, closely resembles the last section. The augites are, however, slightly more porphyritic, and show distinctly a passage into uralite. The felspars are much kaolinised and show zonal structure. It will be noted that here in this rock the uralitisation of the augite occurs in the decomposed portions of the rock.

VI.—Dyke Rocks.

The intrusive character of the Mount Dromedary granite and of the volcanic rocks associated with it, is well borne out by the number of dykes which pass from these masses into the rocks which they have intruded. Felspathic dykes intrude both the andesite and the slates, and dykes referable to the andesite and to the augite-felspar-mica rock intrude the slates near their junction with these rock masses. These intruded dykes are well seen in the sections exposed on the coast from Little Lake to about one mile north of the mouth of Tilba Tilba Lake. They are, however, more abundant in the latter position.

(1.) *Andesitic and Augite-Felspar-Mica Dykes.*—These chiefly occur intruding the slates. Slide No. 280 is from a thin dyke very much decomposed, which has intruded the slates, about half-way between the Little Lake and Tilba Tilba Lake. In its general microscopical characters it somewhat resembles Slide No. 276, which is described above as an augite-andesite. It is, however, much decomposed, although the minerals are still recognisable. Like the section referred to, it is somewhat doleritic in texture, but not so coarsely crystalline, and consists chiefly of kaolinised triclinic felspars, minute hornblendes, and magnetite with irregular shaped micro-porphyritic augites, which show no crystalline form, and present minute clear portions of undecomposed augite, appearing between a mesh-work of dark greenish opaque material, probably a decomposition product. The relative abundance of decomposed hornblende present would rather favour the view, that the dyke is connected with the andesitic rocks.

Slide No. 290 is taken from a dyke intersecting the slates about a mile north of Tilba Tilba Lake, and exhibits portion of an included fragment of foreign rock One end of the section shows a fine grained purely felspathic rock, containing a few isolated decomposed crystals of hornblende, which are full of magnetite grains The other portion consists of a porphyritic rock, the base of which is made up of minute triclinic felspars, with augite, a little glass, and very little iron ore. This base is thickly studded with micro-porphyritic and porphyritic crystals of hornblende, augite, and zonally-built triclinic felspars, with a little mica, which may possibly be secondary. The hornblende and augite are in well formed crystals, each mineral showing its characteristic cleavage, and both being of a pale claret colour. The most abundant porphyritic constituent is in dull green coloured masses which are probably vertical sections of uralitised augite. This portion of the rock, which represents the mass of the dyke, has quite an andesitic character (Pl. X, Fig. 6).

Slide No. 305 is from a dyke cutting the slates in the same locality as the last. Like it, it is holo-crystalline, and possesses a doleritic texture. It consists of triclinic felspar, with apatite, augite, and a little mica which, however is chiefly enclosed in the augite. Apatite is very abundant both in the felspar and augite, the iron ores being similarly distributed. The felspars are slightly opaque, and the augite is of a pale green colour full of inclusions, and has undergone considerable decomposition. In some cases the brown mica seems as if it were primary, and had been intercrystallised with the augite. This dyke rock is certainly allied to, if not identical with, the augite-felspar-mica rock above described.

(2.) *Felspathic Dykes.*—These dykes are chiefly developed in the slate-rocks in the vicinity of their junction with the augite-felspar-mica rock, about a mile north of the Tilba Tilba Lake entrance. Similar dykes also occur traversing the andesite to the south of the lake, and can be seen in the bluff which forms its southern head. They are never of any great width, and in the former locality have intruded the dark-coloured ultra basic dykes, as well as the slates. There is every reason to believe that they are connected with the intrusive granitic mass of Mount Dromedary.

Slide No. 281 is taken from a felspathic dyke at the point where it intersects one of the dark-coloured ultra basic dykes. It is much decomposed, and is porphyritic by triclinic felspar and hornblende, the former of which is quite opaque, while the latter, although full of dark-coloured bands, still show remarkably distinct pleochroism. The general base of the rock is felspathic, but from its decomposed condition the component felspar crystals are barely recognisable. Quartz is by no means frequent, and the whole rock is saturated with ferruginous material. It may be classed as a felspar-hornblende porphyry.

Slide No. 296, from same locality, is almost identical in structure and mineral constitution with the last, but has undergone less decomposition, and contains a good deal of secondary quartz.

Slide No. 297, from the same locality, contains a fair amount of primary quartz in the base. The porphyritic hornblendes are wholly decomposed into epidote. The triclinic felspars are, however, as a rule clear, and show a considerable amount of zoning. This rock might be termed a granite porphyry.

Slide No. 303, from same locality and similar to last, is a granite porphyry.

Slide No. 301 from same locality. This dyke differs entirely from those just described in structure. It has no porphyritic constituents, and consists of microscopic crystals of triclinic felspar with hornblende, which has been altered into epidote and quartz. It might, therefore, be classed as fine-grained hornblende granite.

VII.—Sedimentary Rocks altered by contact.

The effects produced in the sedimentary strata by their contact with the intrusive rocks and their dykes has been considerable. The position in which these results are best seen is about a mile north of the mouth of Tilba Tilba Lake. in the neighbourhood of the actual junction where the dykes are best developed, In all cases there has been induration of the sedimentary strata, accompanied by minute contortion of the lines of original sedimentation, and the development of a schistose structure, made apparent under the microscope by the presence of alternate layers of minute hornblende crystals, which have undoubtedly been developed in the rocks as a result of the metamorphic action set up by the intrusive rocks and their dykes. The minute contortion is more marked in the case of the slates than of the sandstones, which have simply been altered into hornblende schists.

Slide No. 283, is from the actual contact of the augite-felspar-mica rock with the sedimentary rocks about a mile north of the mouth of Tilba Tilba Lake. It is a sandstone which has been metamorphosed by the developement of hornblende into a hornblende schist. The hornblendes are very minute crystals arranged in wavy layers alternating with angular quartz-layers. There is a good deal of ferruginous material present

Slide No. 304 is from a few hundred yards further north, and is from the contact between a thin ultrabasic dyke and a bed of sandstone. Here the development of hornblende has not been so great, and the schistose character is not so well marked.

Slide No. 291 is also from the same neighbourhood, and is a slate rock altered by contact with this dyke. Its presents minute contortion of the laminæ, which are broken up and separated from each other, the interspaces being now occupied by mosaic or secondary quartz. It therefore exhibits an irregularly schistose structure.

Slide No. 288 is from the same neighbourhood, and has been altered by contact with a dyke. It has originally been a finely laminated siliceous rock, the plications of the laminae are in one part of the section, so acute at their apices that they present remarkably good examples of the formation on an exceedingly minute scale of reversed faults. Hornblende microliths have been developed in alternating wavy layers so as to form the rock into a hornblende schist.

Slide No. 302 is from same locality. It occurs as an included fragment in an andesitic dyke, and is an argillaceous slate, the only alteration produced being that the laminæ assume a slightly wavy aspect.

Slide No. 286, from same neighbourhood, presents a greenish rock composed of decomposed hornblende microliths with veins of secondary quartz.

Slide No. 279 is from the coast between Little Lake and Tilba Tilba Lake, at the southern junction line between the andesite and the sedimentary rocks. It represents a siliceous rock which has been intruded by fine strings of the andesitic rock. Its general mass consists of angular and subangular grains of quartz embedded in a dark argillaceous matrix. In some portions of the section the angular quartzes are mixed up with the intruding rock, and in others the intrusive strings are well defined and their contact lines with the sedimentary rock distinctly marked. The intruding material is without doubt the andesitic rock, the base consisting of minute crystals of triclinic felspar and magnetite with porphyritic crystals of decomposed hornblende and felspar. Apparently the only effect produced on the sedimentary rock by the intrusion is the development in the neighbourhood of the contact lines of a great quantity of green material, which is probably decomposed hornblende. Crystallisation of the quartz has not been induced, although isolated grains of quartz have been caught up and surrounded by the matrix of the intruding andesite.

VIII.—General Conclusions.

Conclusions as to intrusive character and age of Granites.

The junction lines of the granitic masses, just described, with the slates, as far as I have had an opportunity of examining them, indicate that they are of an intrusive character as regards the Silurian sedimentary rocks. As a rule their contact lines are sharp and well defined, while in many cases the slates, which in their neighbourhood have undergone considerable induration and tilting, can be seen dipping off the granite. Additional proof of their intrusive character is afforded by the fact that in a few localities the slates in the vicinity of the junction have been intruded by felspathic dykes and veins which intersect them from the granite. Instances of such dyke-like intrusions can be seen in the neighbourhood of Moruya, Cobargo, and also on the coast to the east of Mount Dromedary. It may here be stated that as far as my observations have gone every granitic mass which I have seen in this Colony is intrusive. In no instance have I noted the occurrence of a metamorphic granite. The metamorphism of the slates near their junction with the granite has always been merely such an alteration as would be produced by contact with a heated intrusive rock, and never the gradual passage from an unaltered slate-rock through schistose and gneissic rocks into an undoubted granite. This subject will, however, be systematically dealt with at a subsequent date in a petrological monograph on the acidic rocks of New South Wales, which it is hoped may be shortly undertaken. At the junction of the granitic mass with the slates near Burrowa, in the southern portion of the Colony, there is a typical example of the effects produced by an intrusive granite. Here we have a limited area of slate-rocks in which a schistose gneissic structure has been induced by the intrusive rock, but this has not obliterated the actual line of contact, while in the slate area beyond this reefs and loads have been formed by the contraction of the granitic mass on cooling.

The granites of the southern coast have been intruded subsequent to their crystallisation by felsitic and porphyry dykes, which, however, are never of any great width, and many of them are probably very little younger than the intrusion and crystallisation of the granites themselves. Most of them possibly represent intrusions of the liquid magma, from which the granite was formed, which have come upwards through cracks produced in the solid granite immediately on its crystallisation, by the contraction of the mass on cooling. A few may be, however, of later date.

From the fact that the granites or their dykes are never found to intrude the Devonian conglomerates which cap the Silurian slates and the granite in various parts of the district, it is more than probable that their intrusion took place prior to the deposition of the Devonian rocks, the approximately horizontal position of which tends to support this idea. Their intrusion, therefore, probably dates between the Upper Silurian and the deposition of the Devonian conglomerates, the exact position of which in the Devonian Series has not yet been worked out.

As regards the andesitic rocks, it is impossible to say, at present, because of the non-exhaustive examination which has been made of the district, whether the hornblende-andesite occurring inland from the Tilba Tilba Lake has been a lava or an intrusive rock. There is, however, very little doubt that the augite-andesite forming the southern head of the lake is intrusive, as shown by the occurrence of a dyke of this rock intruding the slates between the Little Lake and Tilba Tilba Lake. Its relations to the augite-felspar-mica rock occurring to the northward have not been made out, as there are no sections of the junction exposed. The latter rock is, however, undoubtedly intrusive, its junction with the slates being distinctly seen, and the dykes which traverse the slates near that junction can be traced back to it. These dykes have subsequently been cut by the felspathic dykes of the granite, showing that the intrusion of the augite-felspar-mica rock was anterior to that of the granite.

The rocks termed propylites or propylitic andesites are quite recognisable as decomposed andesites. They have originally consisted of essentially the same minerals, and have the same structural arrangement, but have undergone great decomposition. The felspars have become largely kaolinised, the amphibole has been replaced by chlorite and epidote, while the pyroxene generally passes into uralite, which has subsequently decomposed into chlorite. The positions in which the propylitic rocks occur would also favour this idea, for they are only present near the junction lines of the felspathic dykes and the granite, positions in which decomposition would most readily take place.

One of the most important facts elicited from a study of the Mount Dromedary rocks is the mode of occurrence of uralite. As will be seen from the above descriptions, it occurs in two rocks which are essentially different rock species. It is present in certain portions of the andesite and also in the augite-felspar-mica rock. In both instances it occurs in those positions in which decomposition has been able to go on to a large extent. In the andesite it occurs in the propylitic portions near the line of contact, where the facilities for decomposition have been very great. In the other rock it also occurs only in the decomposed portions. It would therefore seem to me probable that the chief factor in the alteration of the augite into uralite in these rocks had been ordinary decomposition. There is no doubt that in the neighbourhood of the contact lines the pressure must have been greatly increased at the time of the intrusion of the granite, as is indeed shown by the production of glassy breccias in these positions. It is doubtless true that the pressure referred to exerted a certain amount of influence on the production of uralite from augite, but I think that the facts exhibited by the occurrence of uralite in these rocks point to the effects of decomposition rather than pressure as having been the chief factor in the alteration.

The local effects of intrusion on various rock masses are well seen in the sections exposed on the coast to the east of Mount Dromedary. To the north of Tilba Tilba Lake we have the metamorphism produced in the sedimentary rocks resulting in their alteration into hornblende schists, while to the south of the lake we see the effects produced by an intrusive plutonic rock on an essentially crystalline eruptive rock. In the latter case the result exhibited in the two rocks in the immediate neighbourhood of the line of contact has been as follows:—The passage of the one rock into the other is by no means a gradual metamorphism, but there seems to be a distinct line at which the metamorphism of either rock ceases. The granite has passed into a granitic porphyry, and the latter into a fine-grained felspathic rock which forms the actual contact zone, the difference in texture being merely due to the differential rate of cooling induced by the contact with the intruded rock. On the andesitic side of this contact line we have the alteration of the andesite into a propylite chiefly by decomposition and the development of felspars in the rock consequent upon the intrusion of the granite. Similar results have been produced by the intrusion of the dykes of these rocks, with the addition of the formation of glassy breccias along the actual lines of contact.

XXII.—Descriptions of four Madreporaria Rugosa—Species of the Genera *Phillipsastræa*, *Heliophyllum*, and *Cyathophyllum*—from the Palæozoic Rocks of N. S. Wales: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plates XI and XII.]

I.—Introduction.

THE genus *Phillipsastræa* has already been recognized in New South Wales. The late Prof. de Koninck[*] recorded the occurrence of *P. Verneuilii*, Ed. and H., in the supposed Devonian of Cope's Gully, near Hanging Rock, but this species has not yet come under my notice. I believe I am correct in saying that *Heliophyllum* has not hitherto rewarded the efforts of collectors. For the specimens now described I am indebted to Mr. Rule, of the Technological Museum, Melbourne, who received them from near Yass. Several species of *Cyathophyllum*, both Silurian and Devonian, have been described, principally from the latter formation, and chiefly by Prof. de Koninck. It, however, yet remains to be satisfactorily proved that the localities ascribed to the Devonian are actually within the boundaries of rocks of that age, a fact of which I am at present not convinced.

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[*] Foss. Pal. Nouv.-Galles du Sud, 1876, Pt. 2, p. 69.

Of the *Phillipsastræa*, I owe one to the kindness of the Rev. J. Milne Curran, Mineralogical Lecturer to the Technological Branch of the Department of Education, who obtained it at the Limekilns, seventeen miles north of Bathurst; the other to that of Mr. J. A. Wall.

The *Cyathophyllum* was collected by Mr. John Mitchell, of the Public School, Narellan, at the Cave Flat Caves, Murrumbidgee. On another occasion, when in company with him, I had an opportunity of observing its mode of occurrence at the locality in question and obtaining additional specimens.

For the largest *Phillipsastræa* I propose the name of *P. Currani*, for obvious reasons; for the smaller, that of *P. Walli*; for the *Heliophyllum*, that of *H. yassense*; and for the *Cyathophyllum*, that of *C. Mitchelli*, the object of which will be equally apparent.

II.—Phillipsastræa Currani, sp. nov. [Pl. XI, Figs. 1-6.]

Thanks to the researches of Dr. A. Kunth* the confusion which existed in the use of the names *Phillipsastræa* and *Smithia* has now ceased to exist. The Author in question showed the identity of the two, and, amongst other curious points, brought to light the fact that the same species had been used by Edwards and Haime as a type for the two supposed genera. According to the latter authors the corals in question depended for their separation on the presence or absence of a spurious columella, or columellarian tubercle. It would appear that this feature is of too unstable a character to be of much value, and that its presence, therefore, in *Phillipsastræa*, and absence in *Smithia*, cannot be accepted as a point of generic importance. The views of Kunth have been accepted by Dr. Clemens Schlüter,† Prof. F. von Roemer,‡ and Prof. H. A. Nicholson.§

Phillipsastræa Currani forms flat tabular masses of some thickness, but without any tendency, so far as the examples which have come into my hands reveal it, to a superposition of strata, nor have they been sufficiently perfect to betray the presence of an epidermis. The weathered surface of the corallum is flat, or very slightly undulating, the margin of each calice being marked as a well defined monticulose rim, and the central tabulate area projecting above it, as the result of weathering. The corallites are from eight to ten millimeters broad, the calices on an average about four, whilst the intercalicular areas, between the centres of contiguous corallites, are generally ten millimeters. In a polished horizontal section (Pl. XI, Fig. 2.) the boundary of each corallite can be pretty accurately determined, notwithstanding the absence of walls, by the change in direction, or geniculation, of the septa. The monticulose edge of each calice is always darker than the remainder of the corallum, arising from the number and contiguity to one another, of the transverse dissepiments within the interseptal loculi. This apparently thickened circlet is sometimes known as the "inner mural investment," or "mural circle," but there is no defined wall, as will shortly be seen from the description of a vertical section.

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* Briträge zur Kenntniss fossilen Korallen, No. 5, *Zeitsch. Deutsch. geol. Gesellsch.*, 1870, p. 30.
† Verhandl. natur. Vereines preuss. Rheinl. u. Westf., 1881, XXXVIII, p. 199.
‡ Lethæa geognostica, Thiel 1, Lief. 2, 1883, p. 389.
§ Man. Palæontology, Third Edition, 1889, p. 290.

Turning our attention now to a thin horizontal section (Pl. XI, Fig. 3.) prepared for the microscope, we find the septa to be from twenty-eight to thirty-two, equal, strong, and somewhat thickened, wholly confluent, straight, a little curved, or generally slightly geniculate. The equality of the septa in length is a marked feature in this species, there being no separation into long and short, primary or secondary, and all stopping short at the mural circle, and in no way impinging on the central tabulate area. At the immediate periphery of each corallite, and where the confluence of the septa of contiguous individuals takes place, the former are thin, but as the mural circle is approached the septa become thicker, but there is not the slightest trace of the primordial septal plate, the structure of each septum being quite homogenous. Around all the corallites there are certain septa, usually five, stouter than the others, and strongly geniculate, assuming a triradiate appearance, and apparently acting as the main union of contiguous corallites one to the other. Many of the septa indistinctly present small-toothed lateral outgrowths, faintly observable, which correspond to the "carinæ" on the septa of *Heliophyllum*. When highly magnified they are seen to be integral portions of the septa themselves; and project alternately on each side as irregular thorn-like bodies.

The interseptal loculi are closely filled with dissepimental vesicles, the cut edges of which are sometimes convex inwards, sometimes outwards, but they become rather irregularly vesicular towards the imaginary peripheries of the corallites, or at that point where the septa become confluent. The inner mural investment, which, by the way, is no investment at all in the sense of a wall, is formed of closely set dissepiments convex outwards. A much better term for this portion of the economy is that of "mural circle" employed by Edwards and Haime.

The central area is filled with irregularly vesicular tabulæ, the cut edges of which are always visible in a transverse section, although one or two calices have been observed devoid of them, and filled with clear calcite, probably resulting from the fact of the section being taken between two complete tabulæ. There is no columella, or even a columellarian tubercle, no pali, nor is there a distinct fossula that I can distinguish.

In a vertical section (Pl. XI, Fig. 4.) the tabulæ are distinctly visible occupying the central area, either completely extending across from wall to wall, or as before described, incomplete and vesicular. Furthermore, there is a gathering up of some of them, as it were, in the middle line, into a continuous laminæ, which if cut transversely might give rise to the appearance of a spurious columella. The distance apart of the tabulæ is also variable. The absence of any structure approaching that of a wall, either at the imaginary periphery of the corallites, or within its supposed boundaries, is also very apparent, the distinction between the tabulate area and the septal zone being formed by the closely packed zones of vesicles previously described. The intimate, close, and copious nature of these is likewise conspicuous, gradually enlarging, and becoming looser in arrangement and formation as the outer zone of vesicular tissue in the interceptal loculi is approached.

The irregularity described as existing in these dissepimental vesicles in the outer portions of a corallite, when viewed horizontally, is produced by their copious development and arched outline, the line of section cutting them in different positions and at varying angles.

A vertical section also shows the marked triareal division of the corallites, a feature which recalls to our minds the structure of the Cyathophyllidæ.

Phillipsastræa Currani possesses the general characters of the genus sufficiently to render it a typical species, but the more important features of its structure at once set it apart from its fellows. It differs from *P. radiata*, Phill.,[*] from the Carboniferous Limestone, *P. Hennahi*, Lonsd.,[†] and *P. Pengellii*, Ed. and H.,[‡] of the Devonian, by possessing septa of the one order only, each of the species mentioned being provided with both primary and secondary. The two last-named are also provided with pali. *P. Currani* is distinguished from *P. Bowerbanki*, Ed. and H.,[§] and *P. boloniensis*, Blainv. sp.,[‖] by the large increase in the number of its septa, the former is also a much smaller species, and altogether different to the Australian form. In *P. Verneuili*, Ed. and H.,[¶] the septa are far more numerous than in our species, they are also linear merely in the central area, and tent-shaped outside it. The almost gigantic size of the American species *P. gigas*, D. D. Owen,[**] and *P. Yandelli*, Römínger,[††] renders any further comparison almost superfluous, but in the first-named the septa are very numerous, and unite on the floor of the calice in a small twisted central boss. In *P. cantabrica*, De Vern.,[*] and *P. torreanum*, Ed. and H.,[†] the septa are too limited in number. Lastly, with McCoy's *P.* (*Sarcinula*) *tuberosa*,[‡] our species agrees in possessing nearly the same number of septa, but in this Carboniferous form they are "slight and very delicate laminæ."

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[*] Edwards and Haime, Mon. Brit. Foss. Corals, Pt. III, Carb., 1852, p. 203, t. 37, f. 2, 2a.
[†] Ibid, Pt. IV, Dev., 1853, p. 240, t. 54, f. 4.
[‡] *Loc. cit.*, p. 241, t. 55, f. 1.
[§] *Loc. cit.*, p. 241, t. 55, f. 2.
[‖] *Cyathophyllum*, *Loc. cit.*, p. 230, t. 52, f. 1, 1a.
[¶] Archiv. Mus. Hist. Nat., 1851, V. p. 447, t. 10., f. 5.
[**] Römínger, Geol. Survey Michigan. Lower Peninsula, 1873-1876, III, Pt. 2, p. 129, t. 37.
[††] *Loc. cit.*, p. 130.

The similarity in size of the septa appears to be an important feature in our species. Several authors, for instance Edwards and Haime, and Röminger, refer to the septa as always being longer and shorter. The latter author remarks[§]—"Cycle of the lamellæ composed of alternately longer and shorter ones; the longer lamellæ unite in the centre, and form a pseudo-columellar, nodular protuberance, but do not connect into a continuous vertical axis." The uniform size of the septa, therefore, in this species must be regarded as one of some importance, and a point in which it departs from the otherwise typical features of the genus *Phillipsastræa.*

III.—Phillipsastræa Walli, sp. nov. [Pl. XI, Fig. 7].

I take this opportunity of describing a very peculiar species of the present genus, which I owe to the kindness of Mr. J. A. Wall; it is, however, at once distinguished from the preceding by the decrease in the number of the septa, size of the calices within the "mural circles," and the distance of the corallite centres apart. The rock containing this specimen, judging from its appearance, must have undergone considerable alteration, as the characteristic septa in the intercalicular areas have more or less disappeared, but, strange to say, the mural circles, and the septa in their immediate vicinity, are retained in an excellent state of preservation.

The exact form of the corallum and appearance of the surface are unknown, the specimen having reached my hands only as a fragment fit for sectioning; it is so obviously different from *P. Currani* that I do not hesitate to describe it as distinct.

The calices are small, not more than one and a half millimeters in diameter, distant from one another and separated by considerable intervals of septal surface. The septa are twenty in number, and very constantly so, alternately larger and small, but not differing in thickness. The primary extend inwards to the centre of the calice, as ten very well-marked and prong-like lamellæ, converging to the centre but not meeting absolutely, nor in any way becoming twisted. The secondary septa do not extend beyond the mural circle. The latter is formed by from two to four cycles of dissepiments, each cycle in one plane, and their convexities directed outwards from the circle. In places on the intercalicular areas the general mass of dissepiments are faintly visible, and they seem to have the convex side pointing inwards, as distinguished from those immediately around the calice. Wherever the septa are visible over this area they are found to be invariably confluent as usual in this genus, so that any question which might have arisen regarding the generic affinity of this coral is set at rest. In some cases the calices are filled with clear calcite, in others with the peculiar grey sclerenchymatous matter composing the general mass of the coral, which, at the particular point in question, may perhaps represent tabulæ, but the absence of a vertical section must leave this point in doubt. The calices are from three to six millimeters apart.

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[*] Edwards and Haime, Mon. Brit., Foss. Corals, Pt. IV, Dev., 1853, p. 242, t. 56, f. 2 *a–e.*
[†] Archiv. Mus. Hist. Nat., 1851, V, p 452.
[‡] Brit. Pal. Foss., Fas. 1, 1851, p. 110, t. 3 B., f. 8.
[§] *Op. cit.*, p. 128.

This delicate coral is obviously allied to *Phillipsastræa Bowerbanki*, Ed. and H.,* and even some small varieties of *P. Hennahi*, Ed. and H.† It is named *Phillipsastræa Walli*, in compliment to Mr. Wall, the collector, who has been instrumental in supplying me with several interesting corals from the Yass District.

IV.—*Heliophyllum yassense*, sp. nov. [Pl. XI, Fig. 8; Pl. XII, Figs. 1–3].

Heliophyllum is known to occur in a limited degree in the Middle Devonian rocks of Europe and the Upper Silurian of America, but is plentifully developed in the Devonian rocks of the latter country. I am not in a position at present, I regret, to say whether the present specimens are from the Devonian or Upper Silurian of the Yass District, but in all probability they are from the latter.

The species about to be described as *H. yassense* is peculiar for the great development of its septal system, the extreme tenuity of the septa (primordial septal plate), their zig-zag course, and collection into bundles.

Heliophyllum yassense possesses a compound corallum (Pl.XI, Fig. 8.), the corallites growing in small bunches, and occasionally singly. The colony which has come under my notice measures three inches in diameter and two inches in height, the largest corallite being one and a quarter inches in diameter,but a solitary individual measured two inches. When the outward form is visible the corallites are seen to be elongately turbinate, but little curved, and expanding rapidly upwards. The epitheca is not preserved, and the growth annulations are feeble, wide apart, irregular, and obtusely rounded. The calices are exceedingly shallow, the corallites becoming almost flat-topped.

In a horizontal section (Pl.XII, Fig. 1.) prepared for the microscope the following characters are discernible:—The proper wall appears to be very thin, and is continued inwards along the septa as a very slight thickening of the primordial septal plate. The septa vary from one hundred and forty-five to one hundred and fifty, and are unequally developed, although no determinate subdivision into primary and secondary takes place. They are very fine and hair-like, minutely flexuous or zig-zag, extending almost to the centre of the calice, where they remain untwisted, and tail-off on a very small tabulate area. At about two-thirds the width of the calice from the periphery the septa converge together in bundles of six, but they do not actually unite. Here and there a short septum is met with, but they are much too irregular in position to be considered as "secondary" septa. The carinæ are small and thorn-like, alternate on the sides of each septum. Near the centre of the corallite they cease to occur, except immediately round the edge of the small tabulate centre, where they form a pronounced ring.

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* Mon. Brit. Foss. Corals, Pt. IV, Dev. 1853, t. 55, f. 2.

† *Ibid*, t. 54, f. 4a.

As a rule, the more prominent dissepiments filling the interseptal loculi are much bent outwards, geniculate in fact, although a few may be seen here and there convex inwards. Many of the dissepiments are circular or oval when seen in section, a form which can only arise from their perfect condition being that of vesicles, the circular or oval outline representing the cut edges. These are chiefly present in a peripheral zone, followed in an inward direction by the geniculate dissepiments, between which and the tabulate area intervenes the zone devoid of them. The peripheral circlet of vesicles is large, and more or less rhomboidal.

The only evidence of a fossula observable exists in the form of a short tabulate depression on the more convex side of the corallum near the periphery, and is therefore dorsal. Into it two or three indistinct septa are seen intruding themselves.

The presence of stereoplasma to any appreciable extent in this coral has not been observed, the septa being confined almost wholly to the primordial plate; neither is there any in-filling or consolidation in the septal loculi. The central tabulate area is very small, and the tabulæ are incomplete and vesicular.

In a vertical section (Pl. XII, Fig. 3), one of the first points which strikes the observer is the long narrow pipe-like tabulate area, with both complete and vesicular tabulæ. At the peripheries of the corallites the large marginal rhomboidal vesicles are a prominent feature. Passing towards the interior of the corallites the large mass of dissepimental vesicles are conspicuous, convex upwards and inwards. Some, however, are bounded by almost vertical walls, which, I think, explains the form of those more or less circular vesicles to which attention was called when describing the horizontal section.

When a section cuts a corallite at all obliquely, as in some parts of the present one, the carinæ of the septa are very plainly visible, and their lateral position on the latter at once becomes apparent.

In addition to the large and often vesicular tabulæ in the calice, other smaller tabulæ are visible amongst the inner or distal ends of the septa. These are always regular, mostly horizontal, and generally complete, and mark the limit of the central area seen in a horizontal section, which is almost non-vesicular.

From the large number of species of *Heliophyllum* known, *H. yassense* may be compared with the following, to which it bears some resemblance. *Heliophyllum confluens*, Hall,* from the Upper Helderberg rocks of New York State, but the number and structure of the septa separate the two at once. *H. eriense*, Billings,† is similar in the structure of the septa, but the corallum is formed of long straight corallites, and the mode of growth is therefore widely different. This is a coral from the Corniferous Limestone. In its mode of growth our species also resembles *H. proliferum*, Hall‡; in fact, it is in this feature a combination of this species and *H. confluens*. The former must not be confounded with a species of the same name published by Nicholson, and antedating that of Hall. *H. proliferum*, Nich.,§ from the Corniferous Limestone, resembles our species in being compound, or rather composite, but differs completely by its much smaller number of septa, and by having these twisted at the centre, and elevated as a columellarian boss.

V.—Cyathophyllum Mitchelli, sp. nov. [Pl. XI, Figs. 9 & 10; Pl. XII, Fig. 4].

This species is a plentiful fossil in the "Siluro-Devonian" limestone at Cave Flat, junction of the Murrumbidgee and Goodradigbee Rivers, Co. Harden, where it was collected by Mr. Charles Jenkins, L.S., and again by Mr. John Mitchell and the Writer. The specimens so obtained form the basis of the present paper.

The corallum is compound, and forms large spreading sub-tabular masses of considerable extent and thickness. The polygonal, but more generally hexagonal, corallites possess an average diameter of ten millimeters. On a weathered surface the walls stand conspicuously above the general surface of the corallum, whilst the calices are shallow with a slightly projecting spurious columella. The corallites are but indifferently soldered together, for on fracture one exterior of the long prismatic tubes is always exposed to view, bearing sub-angular rugæ and irregular transverse growth wrinkles.

A horizontal microscopic section (Pl. XI, Fig. 10) reveals the fact that the coral, with the limestone, has undergone much change and alteration, and rendered the study of the former somewhat difficult. The walls are slightly flexuous, the primoridial wall being distinguishable as a dark line, which easily separates into its component elements during the operation of section making. The primordial septa are not visible as similar dark lines, but each septum seems composed of the ordinary sclerenchyma, and there is no thickening by stereoplasma. The septa vary from forty to forty-four in number, and there is hardly any difference perceptible whatever between primary and secondary. They pass from the periphery in a slightly curved direction to the corallite centres, where the distal ends become commingled and partially twisted to form a slightly projecting pseudo-columella. The interseptal loculi are occupied by dissepiments for about one half the diameter of each corallite, and at that point they cease, with the exception of an occasional irregular one. In the outer area in question the dissepiments are regular transverse bars, slightly convex outwards, and arranged in about five regular cycles. Beyond the inner termination of the dissepiments the central part of each corallite appears to be tabulate, with the septa passing over to partially coalesce in the centre. Scattered throughout this central area are some peculiar dark granular bodies, which do not appear to have any definite arrangement.

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* Pal. N. York. Illustrations Dev. Fossils: Corals, 1876, t. 26, f. 3 and 4.

† Nicholson, Pal. Prov. Ontario, 1874, Pt. 1, p. 281.

‡ Hall, *Loc. cit.*, f. 1, 2, and 5.

§ Pal. Prov. Ontario, 1874, Pt. 1, p. 27.

In a vertical section (Pl. XII, Fig. 4), the bi-areal structure of the corallum is exceedingly well shown. In the outer zone the large dissepimental vesicles are seen between the somewhat distant septa, with their convexities presented inwards and upwards. In the central area the convergance of the septa to commingle at the central point brings them much closer together, and between may be observed the delicate tabulæ. We also have an explanation of the scattered granular bodies seen in a horizontal section, for they seem to be broken off spines, here and there still projecting from the sides of the septa, and reminding us, so far as their position goes, of the septal spines in two perforate corals, *Alveolites Labechii*, Ed. and H., of the Wenlock Limestone, and *A. Battersbii*, Ed. and H., from the Middle Devonian.

I have experienced some difficulty in discriminating amongst the large number of species of *Cyathophyllum* so far published, but morphologically speaking, *C. Mitchelli* appears to approach nearest to *Cyathophyllum rugosum*, Hall,[*] and *C. Palmeri*, Meek.[†] The general habit of the former strongly reminds us of that of the present species, but the calices are too large, although the septa varying from thirty-five to forty-five substantially agree with those of *C. Mitchelli.* As regards the second species above mentioned, *C. Palmeri*, the corallites are again too large, and the septa, from twenty-eight to thirty-four in number, are too few. Furthermore, the spurious columella, although formed of untwisted lamellæ is much more distinct than in our species.

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[*] Geol. N. York, 4th District, 1843, p. 159, No. 32, f. 2; Röminger, Geol. Survey Michigan. Lower Peninsula, 1873–1876, III., Pt. 2, p. 106, t. 37 (upper row).

[†] U.S. Geol. Explor. 40th Parl. (King's), 1877, IV., Pt. 1, p. 33, t. 2, f. 2.

In *C. rugosum*, Hall, Römingcr describes the edges of the septa as crenulated, "the side parts traversed by arched carinæ, which in some specimens are almost obsolete, in others very distinct." This would ally *C. rugosum* with *Heliophyllum*, and still further separate it from *C. Mitchelli*, for although the septal spines of the latter are very peculiar, they can hardly be looked upon as homologous with the carinæ in *Heliophyllum;* and they are confined to the inner ends of the septa, within the central area.

It affords me much pleasure to associate with this coral the name of Mr. John Mitchell, of the Public School, Narellan, with whom I carried out some expolrations at the Cave Flat Caves.

XXIII.—The Cave-Shelters near Wollombi, in the Hunter River District: by P. T. HAMMOND, Field-Assistant.

[Plates XIII–XV.]

THE following Notes were made during an inspection of the Cave-Shelters in the vicinity of the town of Wollombi, some of which give evidence of having been, at one time, tenanted by the Aborigines.

Two of the caves are situated in a small gully about two miles on the northern side of Wollombi Township, within five chains of the Cessnock to Wollombi Road; their position will be seen more clearly by referring to Pl. XIII.

They are within a chain of one another, both facing N.N.W., and are large caverns weathered out of the hard rock, which appears to be one of the finer conglomerates of the East Maitland Coal Measures, which are here dipping in an easterly direction. Smaller caves are frequent in these beds in many places in the neighbourhood, similar to others that I have observed in the Upper Marine beds at Ællalong, and near Richmond Vale and Cessnock, there weathered out of sandstone and the finer conglomerates, and which in some places near Cessnock contain stalactites and stalagmites of considerable magnitude, owing their origin to the infiltration through the marine beds of water holding carbonate of lime in solution derived probably from the marine shells, which occur in numbers in some of the surrounding strata.

The larger cave (Pl. XIV., Figs, 1 and 2), is entered by a small opening almost concealed by grass and creepers, being only about eighteen inches above the ground, so that it is necessary to go on hands and knees in order to enter, and the interior being so dark as to necessitate the use of candles. It is a large somewhat elliptical chamber, the walls of which are rough and pebbly, and covered to a height of six feet with names written by visitors, but showing no aboriginal drawings or carvings, and the mound of earth which forms a crescent along the whole length of the cave had evidently been washed in by floods, and contained neither shells, flints, nor implements of any description, and indeed in time of flood would not be habitable. The cave is fifty-seven feet long by twenty-four feet broad and fourteen feet high in the highest part, having a dome-shaped roof, the entrance is along one side and is partly filled with pebbles and small water-worn blocks of stone, and rubbish carried in by the water. It is hollowed out of a bed of rock which has a perpendicular face twenty-nine feet high.

The other cave is of similar dimensions, with the exception of its height, which is only ten feet, and is roughly elliptical in shape, having a very rugged floor and wall, and, like the one previously described, has nothing to commend it but its size, which is uncommon in a sandstone or conglomerate formation, but about two chains further to the south and facing the west is a cave sixty feet long, showing many aboriginals markings, and having an ash mound at the entrance, from which I obtained a good many examples of *UnioAngasi*, now living in the creeks in the vicinity, and a few sharp-edged flints, which had evidently been carried there and used as skinning knives by the blacks. Some of these, as also the shells, were found at a depth of from two to three feet from the surface of the cave floor, the flints being of quite a different character from any of the rocks I observed in the locality.

The markings on the walls of this cave consisted of representations of twelve hands and portions of hands outlined with, and surrounded by white on the dark background of the rock, and possibly produced by holding the hand flat against the surface of the rock and splashing round it with a white-wash made perhaps from some description of pipeclay or hearth-ash. One of the markings had been cut out and taken away, and another had been worked round probably with the same intention.

Two of the hand markings are large, evidently produced from the hands of male adults, whilst the rest are of much more delicate proportions, some perhaps produced from those of children, or women.

All the hand markings in this cave, with one exception, are those of left hands, the one exception I think being sufficient to prove that it was rather on account of the convenience with which the left hand could be splashed round (the right holding the implement used), than for any purpose of symbolism that the preponderance of left hands is due. It is noticeable also that they occur frequently in groups of three, but this too may be only on account of convenience. This shelter is sixty feet long, the markings and ash mound being principally in the right-hand side of the cave.

Another cave, (Pl. XIV, Fig, 3), the last visited, occurs on the outskirts of the township of Wollombi, at the spot indicated on Pl. XIII, a few chains from the bank of Narrone Creek, and is a horizontally projecting ledge of rock, shelving slightly inwards, the entrance to which faces N.N.E., the height being about seven feet four inches, and running back for fifteen feet, the length being sixty-six feet. This shelter is profusely decorated on both walls and roof, where it could be reached by hands, and has also a drawing done in white, possibly intended to represent the sun, and consists of thirty-eight diverging rays, the whole forming a circular object two feet across. Here are represented both adult and children's feet low down on the wall, splashed in the same manner as the hands, and showing that at the time the cave was inhabited the level of the floor was probably the same as at present, the feet have the characteristic breadth of those of the native race. Right hands are not infrequent in this cave, though here also the left preponderate, and many are evidently those of very small children. Besides these, representations of three boomerangs and a native tomahawk are faintly discernible on the roof, the latter with a hand placed across the end of the handle with fingers outstretched. All the representations in this shelter have been splashed in the usual way with the exception of that of the sun already described, and of a native shield, both of which are sketched in outline. The hands in nearly all cases point upwards or sideways, but there are two exceptions to this rule also. In the case of this shelter, as well as in that of the one previously described, some markings have been cut out and removed by visitors. Most of the chips of flint were obtained from this shelter last described.

I heard of many other caves said to be ornamented with drawings of native animals and birds, at a distance of from nineteen to thirty miles from Wollombi, but I could not obtain information as to exact localities.

The designs on the walls are in a few cases very plain, but in general they are rather faint.

XXIV.—Idiographic Rock-Carvings of the Aborigines at Flat Rocks, near Manly: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate XVI.]

I.—Introduction.

I AM indebted to Mr. J. J. Fletcher, M.A., &c., Director of the Linnean Society of New South Wales, for pointing out some further fine and well-preserved examples of Idiographic Rock-carvings on an eminence about two and a half miles north-west of Manly, known as Flat Rocks. This group is of interest from the presence of fish of large size, and the outline of an animal not unlike a flying squirrel, and not previously noticed in any series. The Flat Rocks carvings were at one time more numerous than now, but lapse of time has rendered many quite indistinct. The following notes and accompanying sketches were made by Prof. T. W. E. David, B.A., Mr. George H. Barrow, and the Writer.

II.—Locality.

The carvings are situated on some rounded surfaces and an inclined plane of Hawkesbury Sandstone, on Portion 1499, Parish of Manly Cove, overlooking Curl Curl Creek, and locally known as the Flat Rocks. The height of the locality is two hundred and seventy-two feet above Curl Curl Lagoon. The sandstone table is as large, if not of greater extent than that on the range above Bantry Bay, from which the carvings have already been described.* In the present instance, the locality has an easterly aspect, with a commanding view of the Pacific Ocean, the low ground around Manly, and portions of the Port Jackson Heads. Here and there over the table the surface has been weatherworn into shallow pond-like depressions, and it is in some of these that the most interesting etchings have been made.

III.—Description of the Carvings.

The method of execution is quite similar to those above Bantry Bay and elsewhere,—a series of preliminary indentations, rendered confluent by subsequent blows, and so producing a grooved outline.

On descending from the higher ground, just off the road-line, the first carving met with is the large fish, Pl. XVI, Fig. 1, twenty-four feet long, which is indented partly on the flat sandstone table, and partly on a rounded, inclined surface, with an easterly aspect. There is a large dorsal, and a small pectoral fin, two large eyes, a rather restricted tail with ill-defined flukes, a transversely oblique band placed just behind the dorsal fin, and two incomprehensible horseshoe-shaped bodies somewhat in advance of it. On the outer margins of the eyes are four slits. The transverse measurement of this fish from tip to tip of the fins is eighteen feet. It will be observed that by placing both the eyes on one side of the head, this fish is rendered lopsided, and on this account becomes a strange mixture of symmetry and asymmetry. The slits can be intended for nothing else but the gill apertures.

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* Rec. Geol. Survey N.S. Wales, 1890, II., Pt. I, p. 26.

The subject of Fig. 2 is also a fish. It lies at the head of, or at right angles to, Fig. 1, and has a decided north-east aspect. Here the native artist has followed out the same idea in rendering it lopsided. He also delineated a dorsal and pectoral fin, and seems to have had an idea of a ventral one also. The tail is large and well-defined. From end to end the present figure measures thirty-one feet nine inches, and the diagonal measurement from fin-tip to fin-tip is nearly twenty-three feet. In this instance the pectoral fin is the longest and most important.

Sub-parallel to Fig. 2, and more or less below Fig. 1, is the remarkable fish represented by Fig. 3, sixteen feet nine inches in length, with a greatest transverse diameter of somewhat over thirteen feet. Three fins are represented, one triangular, which may be looked upon as dorsal, and two contiguous, which on the previous supposition can only be regarded as pectoral. This figure has, within its outline, that of a man. This will be referred to later on.

The remaining objects in contiguity to the larger are in one of the depressions of the sandstone before mentioned, consisting of two shields and two kangaroos. Of the former, Fig. 4 is after the type of one of the Bantry Bay carvings;* neither, however, have any obliquity in outline. Fig. 5, in its expanded apices, differs from any, of which I have yet seen a representation, but it looks as if intended to represent the ends of the shield gathered together and tied. One shield is three feet six inches in length, the other four feet three inches approximately. The larger of the kangaroos (Pl. XVI, Fig. 6), seven feet in height, is as correspondingly rude as the smaller (Pl. XVI, Fig. 7) is well executed The latter is about three feet in length. Near the larger of the kangaroos is the outline of a man, bearing the usual evidences of aboriginal workmanship, such as the peculiarly angular elbow and knee-caps, and outstretched arms.

We now come to the objects, nine in number, represented in the largest of the surface depressions, and removed a few feet from the remainder of the carvings. The first to catch the eye is Fig. 9*a*, Pl. XVI, probably intended for a "hammer-headed shark," the figure measuring nearly five feet. Figs. 9*b* and 9*c* recall similar objects recorded from the Bantry Bay carvings,† believed by some to represent cat-fish; but I would also suggest that they may perhaps be intended to convey the idea of gigantic Holothurians, but their affinity is made still more complicated by the attachment of an oval body to the distal end of one of them (Pl. XVI, Fig. 9*e*). The figures vary from three to four feet long. The depression also contains two fish, one (Pl. XVI, Fig. 9*f*) with the head marked off by a diagonal line, and the other (Pl. XVI, Fig. 9*g*) with a wide gape. The object represented by Fig. 9*h* I am not able to throw any light upon; primarily it seems to be one of the peculiar bodies represented by Figs. 9*b* and 9*c*, with four converging lines from end to end. The last figure is very remarkable, and may perhaps be intended for a flying squirrel (Pl. XVI, Fig. 9*i*), but what the object of the oval body attached to one of the legs is, it is impossible to say.

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* Rec. Geol. Survey N. S. Wales, 1890, Pt. 1, t. 2, f. 9.
† Rec. Geol. Survey N. S. Wales, 1890, Pt. 1, t. 2, f. 15.

We have, in conclusion, still to consider the figure of the man within the outline of one of the fish (Pl. XVI, Fig. 3). The position is identical with one of those on the Bantry Bay Range,* with the arms outstretched. The rounded meaningless head and angulated elbow and knee joints, strong characteristics of the aboriginal human figure, when depicted in this way, are well displayed. A still ruder figure of a man, within that of a fish, is given by Mr. F. Mann,† as occurring at Berry's Bay, where there are two upward extensions of what are probably meant for the arms, without any defined head at all.

The only instance of depicted features, on what is presumedly an aboriginal idiographic carving, with which I am acquainted, is the male figure "on a rock between Brisbane Water and the Hawkesbury River," illustrated by Mr. F. Mann.‡ In this, a full-face figure, holding in one hand a bundle of spears and in the other a boomerang, the eyes, nose, mouth, and a crop of bushy hair are shown. In analysing its authenticity, however, as the work of an aborigine, the rounded outline of the limbs, the facial characters, and the absence of the elbow and knee angularity, should not be lost sight of.

It is, however, a significant fact that the figures of women, so far as my own observation goes, are never met with in these idiographic carvings. Mr. E. M. Curr § has made the same observations with regard to native drawings, more particularly in connection with some remarkable sketches at the Granite Range, head of the Mitchell River.

IV.—Carvings at Little Sirius Bay.

Whilst on the subject of the male figure above referred to, it may not be out of place to notice two carvings of heads in relief at the head of Little Sirius Bay, Mossman's Bay, Port Jackson, examined by Mr. J. J. Patterson, Mr. W. S. Leigh and the Writer.

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* Rec. Geol. Survey N. S. Wales, 1890, II, Pt. 1, t. 2, f. 12.
† Proc. Geogr. Soc. Australasia, N. S. Wales Branch, 1885, Special Vol., 6th Plate, up. r. hand fig.
‡ Proc. Geogr. Soc. Australasia, N. S. Wales Branch, 1885, Special Vol., 4th Plate, l. hand fig.
§ The Australian Race, 1877, II, p. 403.

On the west side of the bay, on the side of a tramway, leading from the quarry above, is a rock shelter, formed by a huge slab of sandstone, resting against the steep hillside, and but a few feet above high-water mark. This spot, according to tradition, was once an important black camping-place. On this slab were said to exist some interesting idiographic carvings, but we were able to find only two rude faces, side by side, cut in relief, about twice life-size, which are very questionably aboriginal.

The relievos are somewhat depressed, generally with squat and broad noses, although the cheeks are prominent, and the eyes apparently closed, whilst one has a deep groove down the centre of the forehead. The expression is anything but pleasing, in fact rather repulsive, and recalls to one's mind more the work of an untutored white than that of one of the Aborigines. They are much ruder even than the head in profile described by Sir George Grey,* on the face of a sandstone rock at the Upper Glenelg River, North-west Australia. This is unquestionably the head of a Caucasian, and I do not for one moment believe that it is the work of an aboriginal artist.

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* Two Expeds. Discovery N.W. and W. Australia, 1837-39, I, 1841, p. 205, plate.

PLATE VIII.

Sketch plan of the Parish of Noorooma, County of Dampier, showing the distribution of the granite and the associated volcanic rocks of Mount Dromedary.

Drawn by Mr. A. H. Tayler.

PLATE IX.

Fig. 1. Hornblende-Andesite, from a mile west of Tilba Tilba Lake. (Slide No. 249 (*b*).)

Fig. 2. Propylitic Andesite, from the bluff forming the southern head of Tilba Tilba Lake. (Slide No. 260.) This rock has undergone much decomposition, and the augite has been converted into uralite.

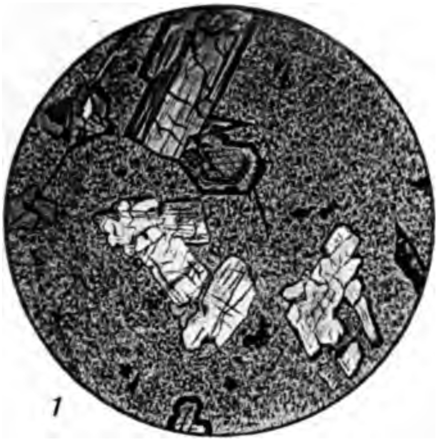
Fig. 3. Individuals of zonally-built felspar, from propylitic andesite. (Slide No 252.) The felspars are probably of secondary origin, many of them having crystallised around a nucleus of iron pyrites.

Fig. 4. Glassy andesitic breccia, from the edge of a felspathic dyke traversing the augite andesite at the southern head of Tilba Tilba Lake. (Slide No. 262.)

Fig. 5. Augite-Granite, from C.P. No. 19, east of Little Dromedary. (Slide No. 238.)

Fig. 6. Augite-felspar-mica rock, from Portion 375, Parish of Wandellow. (Slide No. 265 (*b*).)

Drawn from nature by Mr. P. T. Hammond.



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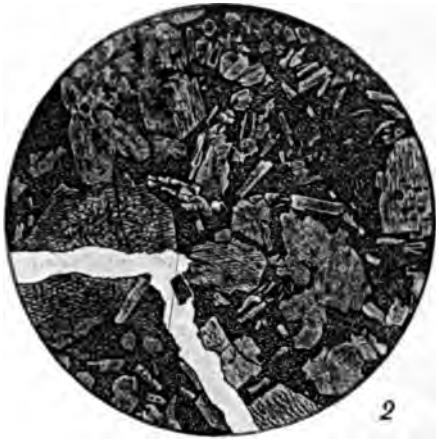

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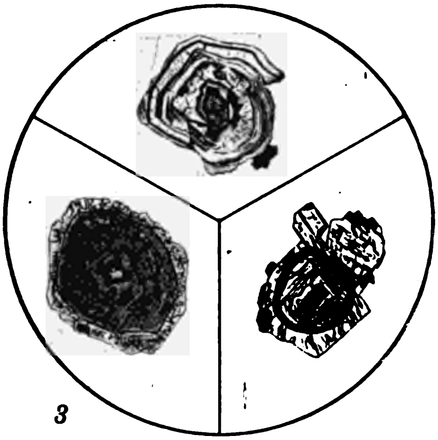

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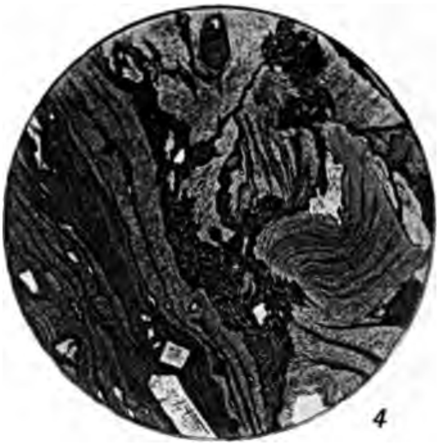

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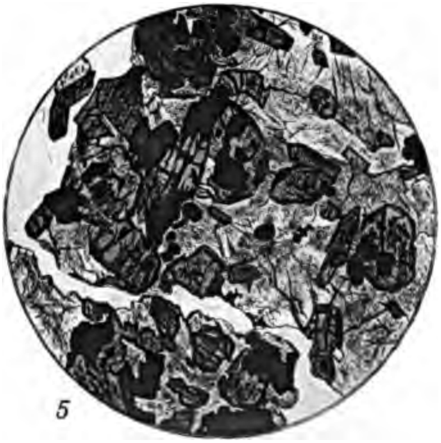

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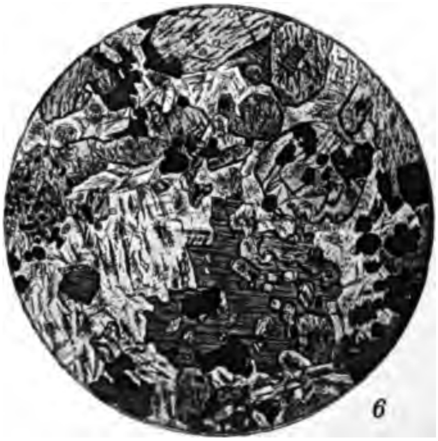

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PLATE X.

Fig. 1. Individuals of triclinic felspar from Moruya granite, showing secondary peripheral growth enclosing minute grains of quartz. (Slide No. 293.)

Fig. 2. Augite-Andesite, from bluff forming southern head of Tilba Tilba Lake (Slide No. 276.)

Fig. 3. Showing the brecciated character of the andesitic rock at its junction with the felspathic dykes, at the south head of the Tilba Tilba Lake. (Slide No. 256.)

Fig. 4. Showing the granitic porphyry occurring at the base of the andesitic clia forming the southern head of Lake Tilba Tilba. (Slide No. 253.) This rock passes gradually into the purely felspathic zone of contact with the propylitic portion of the andesite.

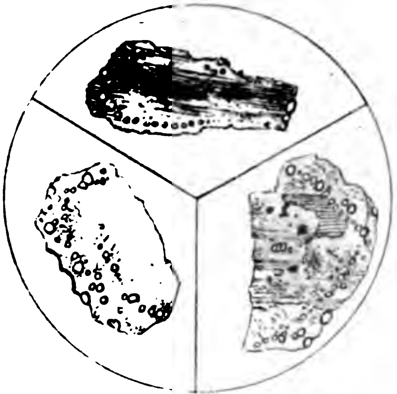
Fig. 5. Purely felspathic crystalline rock forming the contact zone between the granitic and andesitic rocks, from the mouth of Tilba Tilba Lake. (Slide No. 264.)

Fig 6. Andesitic dyke rock traversing the slates about a mile north of the mouth of Tilba Tilba Lake. (Slide No. 290.)

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

11*a* 369—91

Plate X.



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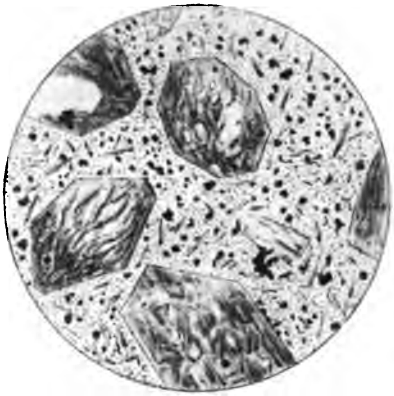

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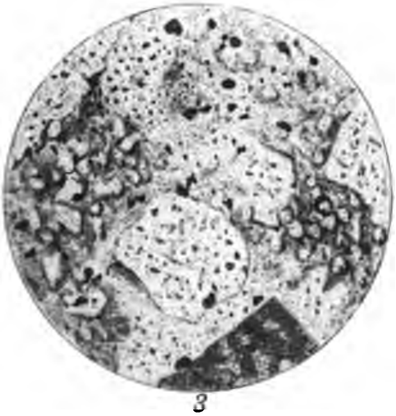

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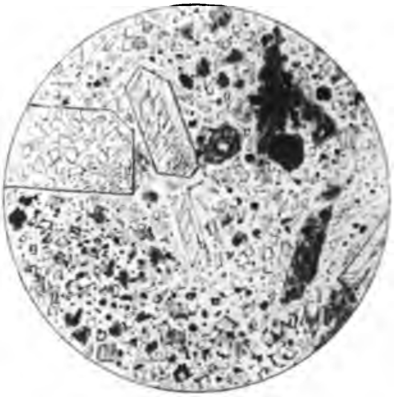

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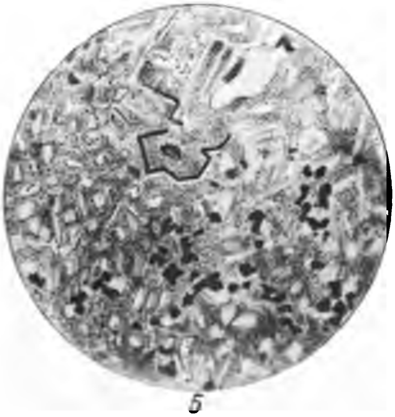

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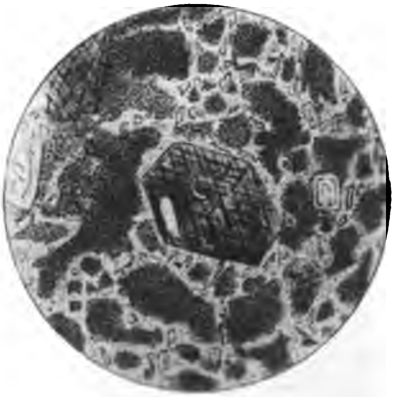

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PLATE XI.

Phillipsastræa Currani, *Eth. fil.*

Fig. 1. Portion of the surface of a weathered example, showing five corallites.

Fig. 2. Portion of a horizontal polished section, showing the anastomosing, and in places geniculate septa, calices, dissepiments, &c.

Fig. 3. Portion of a microscopic horizontal section, in which the geniculate nature of the septa is shown to greater perfection, the vesicular tabulæ in the centre of the corallites, and the dissepiments filling the interseptal loculi.

Fig. 4. Vertical microscopic section, with the visceral chamber in the centre filled with large incomplete tabulæ, with the closely-packed zones of vesicles on each side, and outside this again the interseptal loculi filled with vesicles.

Fig. 5. Three septa, viewed horizontally in section, to show the manner in which they are broken up

Fig. 6. An interseptal loculum, to show the nature of the infilling vesicles

Phillipsastræa Walli, *Eth. fil.*

Fig. 7. Portion of a horizontal microscopic section, showing four corallites

Heliophyllum yassense, *Eth. fil.*

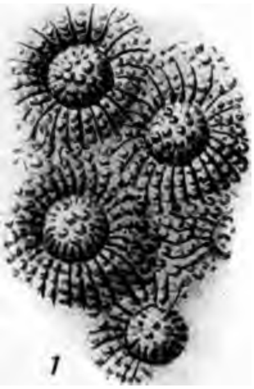
Fig. 8. A colony, exhibiting the mode of growth and general appearance of the corallites.

Cyathophyllum Mitchelli, *Eth. fil.*

Fig. 9. Three corallites, taken from a weathered horizontal surface.

Fig. 10. A horizontal microscopic section, showing the gathering of the septa towards the centre, without uniting.

Drawn from nature by Mr. G. H Barrow, Australian Museum.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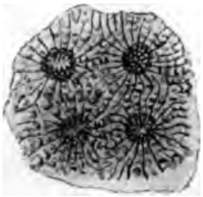
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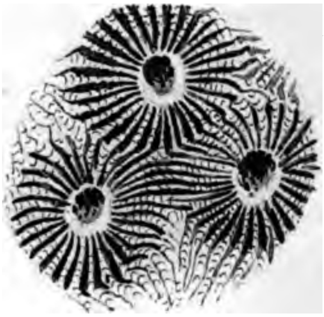
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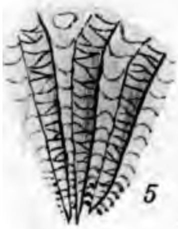
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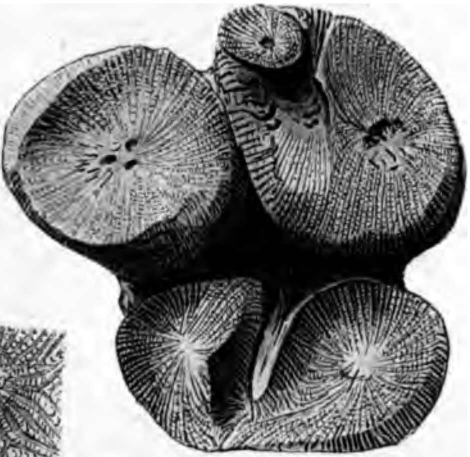
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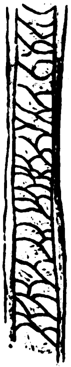
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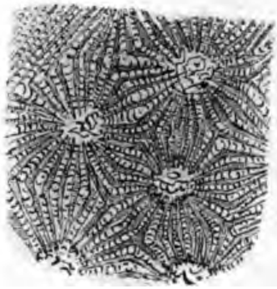
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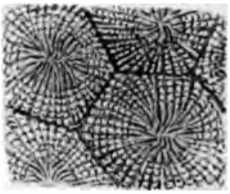
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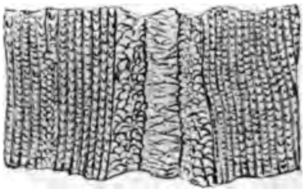
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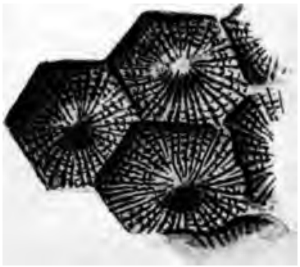
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PLATE XII.

Heliophyllum yassense, *Eth. fil.*

Fig. 1. Microscopic horizontal section, with the innumerable fine, flexuous septa, with a central area unoccupied by dissepiments.

Fig. 2. Four septa enlarged, to show tortuous or zigzag nature, and absence of stereoplasma.

Fig. 3. A partially vertical, partially oblique section, showing the narrow pipe-like nature of the visceral chamber.

Cyathophyllum Mitchelli, *Eth. fil.*

Fig. 4. Vertical section of part of a corallite, with the central zone filled with incomplete tabulæ, and the interseptal loculi with convex superimposed vesicles.

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

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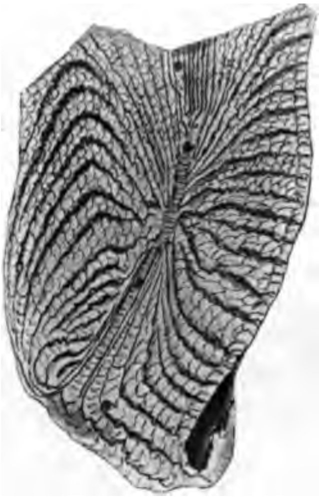

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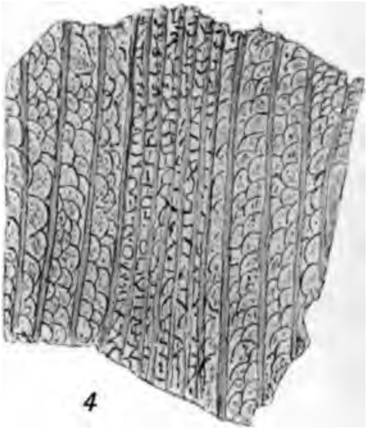

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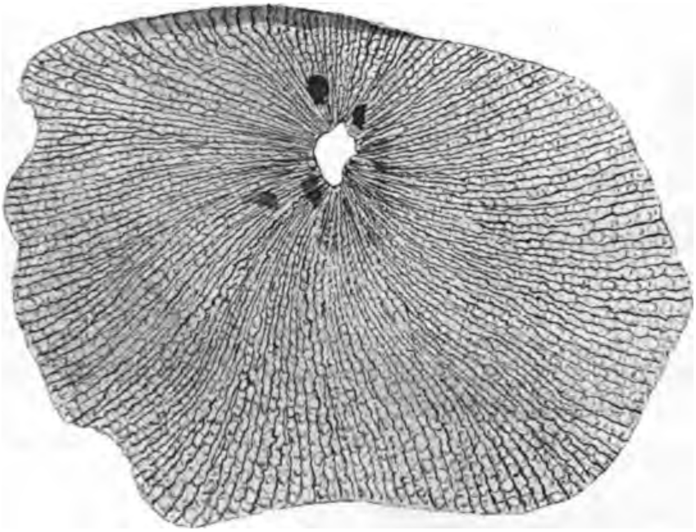

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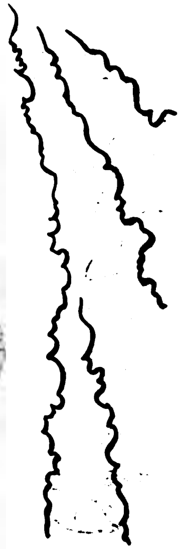

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PLATE XIII.

Plan of the Parish of Corrabare, County of Northumberland, New South Wales, showing the position of the Cave-shelters, near Wollombi.

Drawn by Mr. P. T. Hammond.

Parish of Corrabaree
County Northumberland

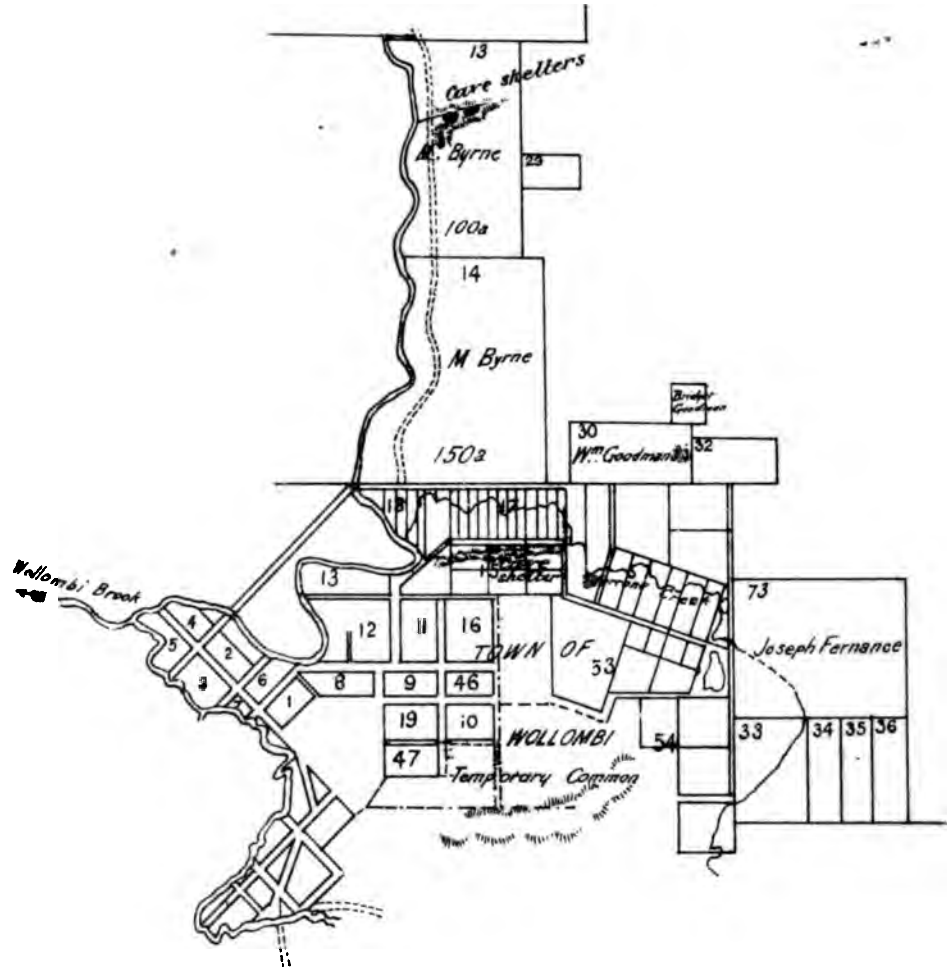


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE XIV.

Wollombi Cave-shelters.

Fig. 1. Transverse section of No. 1 Cave-shelter, showing the small ent
flood deposit on the floor.

Fig. 2. Longitudinal section of the same.

Fig. 3. Transverse section of No. 2 Cave-shelter.

Drawn by Mr. P. T. Hammond.

PLATE XV.

Aboriginal Drawings, Wollombi Rock-shelters.

Group to left—This represents a drawing, probably of the sun, surrounded by hands and feet, the former being principally the right. One, nearly in the middle line, shows how the operation had been interrupted, and the hand replaced in a slightly different position.

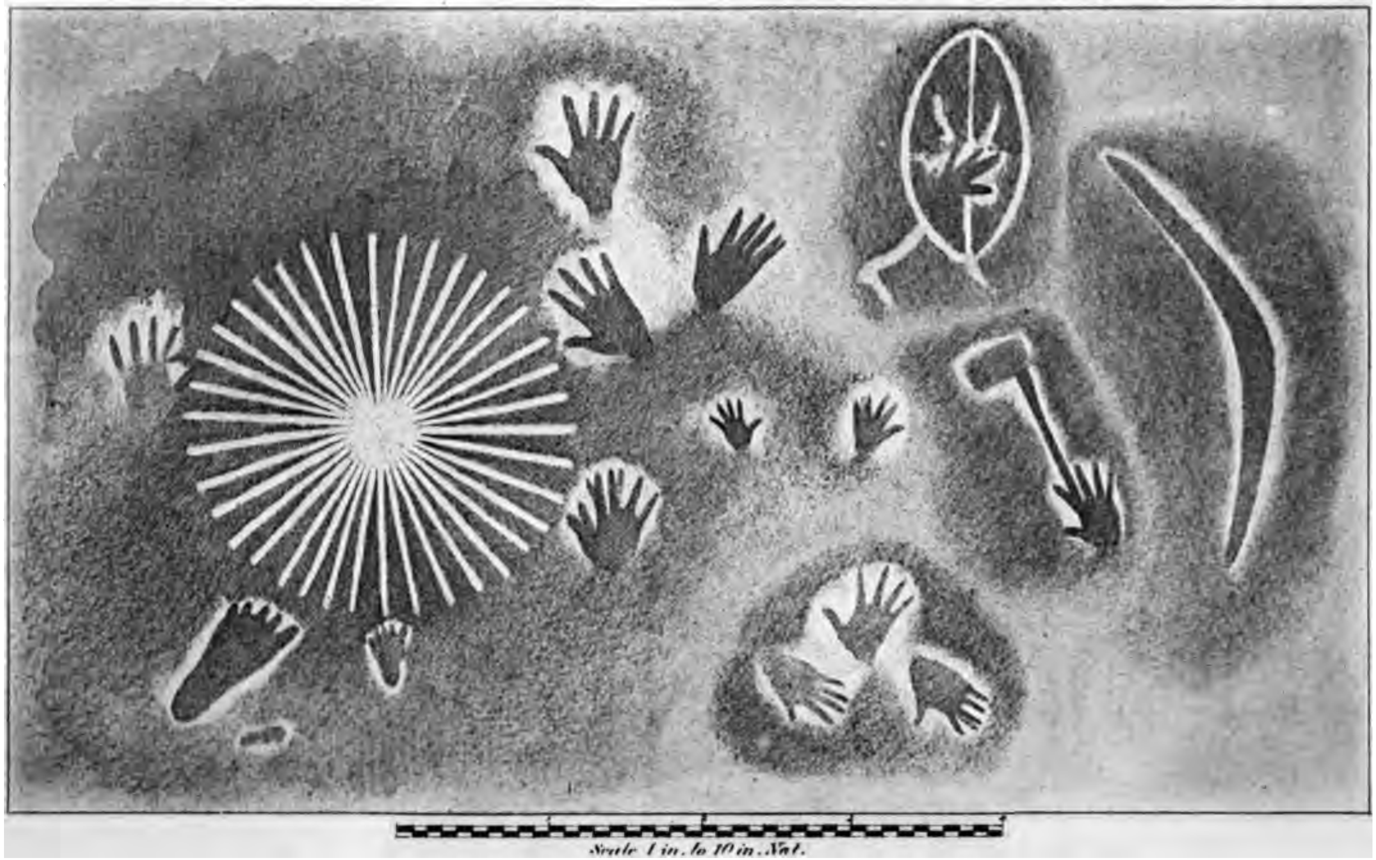
Upper right-hand figure represents a shield with an imperfect hand placed across the middle.

Right-hand figure is that of a well-formed boomerang.

Middle right-hand figure shows a hand probably intended to be holding a tomahawk.

Lower right-hand figure—A group of hands, possibly female.

Drawn from nature by Mr. P. T. Hammond.



Scale 1 in. to 10 in. Nat.

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PLATE XVI.

Fig. 1. Large Fish, twenty-four feet long, indented partly on the sandstone table and partly on a rounded inclined surface.

Fig. 2. Another Fish, lying at right angles to Fig. 1. It is thirty-one feet nine inches long.

Fig. 3. An extraordinary Fish, sub-parallel to Fig. 2, and more or less below Fig. 1, sixteen feet nine inches in length. Within its outline is that of a Man, Fig 8.

Fig. 4. A Shield of the usual type pourtrayed in idiographic carvings.

Fig. 5. A Shield with expanded apices, gathered or puckered together.

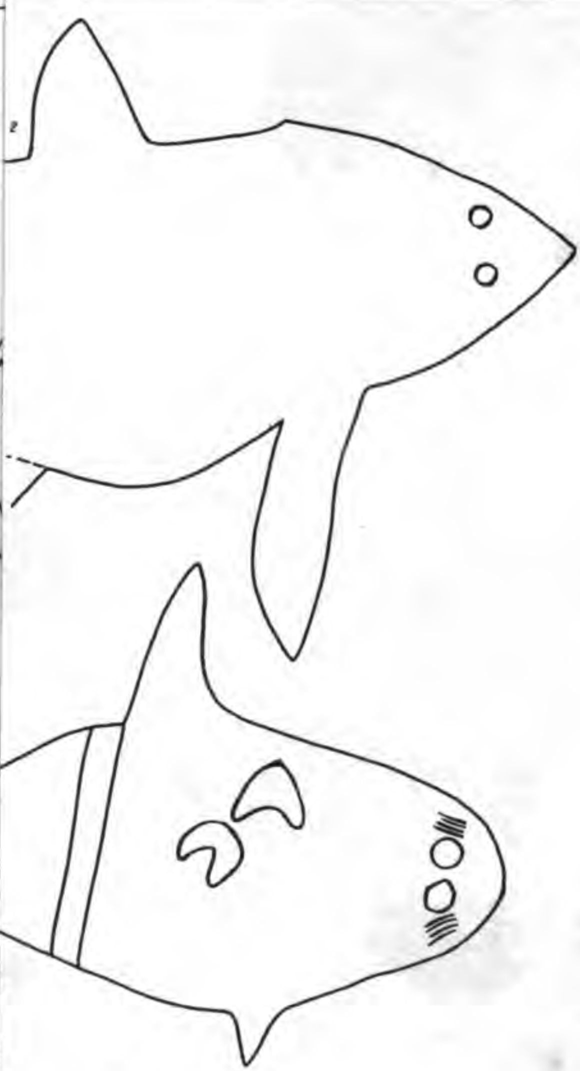
Fig. 6. Rude figure of a Kangaroo, seven feet in height.

Fig. 7. Well-executed figure of a smaller Kangaroo.

Fig. 8. Figure of a Man, possessing all the peculiarities of aboriginal authorship.

Fig. 9. Group of objects in a depression on the sandstone table.
9^a. A Fish, probably a "hammer-headed shark," five feet in length.
9^b,—9^e. Objects of unknown affinity.
9^f. A Fish, with the head marked off by a diagonal line.
9^g. A Fish, with a wide gape.
9^h. Unknown body, but allied to Figs. 9^b 9^e.
9^i. Perhaps intended for a "flying squirrel."

Drawn from nature by Mr. G. H. Barrow, Australian Museum.



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